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MEASUREMENT OF FOOD CROP PRODUCTIVITY AND PRODUCTIVITY REGIONS IN UTTAR PRADESH

ABSTRACT

THESIS SUBMITTED FOR THE DEGREE OF

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IN

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By

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Under the Supervision of

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2160

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Aligarh Muslim University, Aligarh

1980

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ABSTRACT

The assessment of agricultural productivity has recently attracted the attention of a large number of agricultural scientists, geographers, economists etc. Therefore, the concept and methodological procedure has been quantified for its measurement and viewed from different angles i.e., in 'time' and in 'space'. Conceptually, productivity is the ratio between output and input. In other words, it is the arithmetical ratio between the amount produced and the amount of any resources used in the course of production. Quantitatively, if the productivity of a crop in a particular area is increased from 2 qnt. to 3 qnt. by using better seed, better methods of cultivation and more fertilizer etc., the productivity of that land, in the agricultural sense, has been increased by 50 per cent.

The present work is an attempt to analyse the regional variations in food crops productivity of a selected Indian territory. For this purpose the State of Uttar Pradesh has been selected for the reason that the area is intimately known to the writer, and that it is well defined geographical region.

Uttar Pradesh lies between the latitudes of 23°52' and 31°18'N and the longitudes of 77°3' and 84°39'E, comprising fifty-four administrative districts (1971 census)

with a geographical area of 2,94,463 sq. km. of which 48,034 sq. km. (16.30 per cent) in the north is under hilly tract. For the present purpose out of fifty-four, six hilly districts namely, Uttar Kashi, Chamoli, Pithoragarh, Garhwal, Tehri-Garhwal and Almora of the State have been excluded from the study due to non-availability of required informations and partly it supports a very scanty population.

It was proposed to examine crop productivity in each of the forty-eight districts of the State from three broad angles: (i) to measure inter-district variations in crop productivity at a given point of time, (ii) to ascertain changes in productivity between three points of time, and (iii) to assess the growth of productivity during the study periods. For the computation of productivity indices the crops considered are namely, rice, jowar, bajra, maize, wheat, barley, gram, arhar, pulses (including urd, moong, moth and masur), oilseeds (including groundnut, mustard, linseed, castor and rapeseed), sugarcane and potato.

The principal objectives of the study are to make a regional comparisons of productivity spatially and to assess crop productivity variations during three different points of time e.g., 1950-51, 1960-61 and 1970-71. The productivity indices (considering the above mentioned food crops) have been computed with the help of following four productivity evaluating methods:

1. Food crop productivity, based on Yang's Crop Yield Index;
2. Food crop productivity, based on Standard Nutrition Unit output per hectare;
3. Food crop productivity, based on output per-hectare (Rs.), and
4. Food crop productivity, based on output per agricultural worker (Rs.).

Among the four methods considered above, the first method signifies the two aspects of productivity assessment. Firstly, it measures the productivity considering the yield of a crop in a certain unit area with the entire region selected for study. Secondly, it is 'weight sensitive', i.e., the productivity index of a certain unit of study is influenced by the magnitude of area under the spacific crop concerned when it is compared with the entire region.

The second method, Standard Nutrition Unit considers calories as the multiplying factor with the yields of respective crops when viewed from nutritional point, thereby, persons supporting capacity per hectare of cropped land.

The third and fourth methods measure productivity by incorporating prices of the crops as weights considered to get the value of output per hectare/per agricultural worker. The productivity per hectare (method third) of the selected food crops has been assessed by considering the wholesale prices of indivisual crop as the multiplying factor and each product of crops concerned was added up and the final product thus obtained was divided by the total area of the crops considered relating the district concerned. The productivity of agricultural worker (method fourth), too, has been worked out by incorporating wholesale prices of the crops as the multiplying factor to get the value of output (Rs.) per agricultural worker engaged for the production of crops since sowing to harvest times.

Besides these, a detailed account has been produced on the perspectives of agriculture in different parts of the State e.g., the problem of wastelands, ground water resources, size and number of holdings, initiation of intensive cultivation programmes, land use profile, and cropping pattern and crop production levels. In addition to these, role of some important variables like, water and irrigation facilities, area planted under high-yielding varieties of seed, consumption levels of fertilizers (NPK), use of modern farm implements and machinery and the levels of agricultural finance to enable the farmer to adopt modern agricultural strategies are discussed rather in detail.

It was further hypothesized to establish an input-output relationship by selecting a set of twelve independent input variables and a dependent variable i.e., the productivity index relating to the value of Standard Nutrition Unit per hectare (Chapter X). For the statistical formulations, two important techniques of 'factor analysis' and of 'multiple linear regression analysis' leading to the development of Cobb-Douglas production function were performed on Scientific Sub-routine Programme, IMB 1130 Computer. The input and output variables were analysed while considering Uttar Pradesh (forty-eight districts) as a single unit, as well as into different productivity regions for the year 1970-71. At the first instance, among the four productivity evaluating methods, the significant productivity index was tested through factor analysis which yielded SNU output measure as the most significant method of productivity assessment (see Table XLIV). Therefore, the values of selected input variables were incorporated for the identification of significant input variables through factor analysis for U.P. as a whole and also for the productivity regions. After doing factor analysis for determining the significance of variables, linear multiple regression analysis was done while incorporating the logarithmic values of the variables identified. It is also tried to formulate the elasticities of inputs which can bring the change in productivity while other factors remain the same.

In the last Chapter XI same of the measures that can bring the change in productivity spatially are suggested providing them on a scientific basis and in a suitable manner.

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PREFACE

The assessment of agricultural productivity in the national planning is of due importance and can never be overlooked in a country where economy is developing in all sectors. This aspect of agriculture is important also where the man-land ratio is acute, and each hectare of cultivable land is required to support a certain number of persons, in the era of 'Green Revolution' in order to attain self-sufficiency in food production. As a result of many studies in the field of productivity measurement the relationship between gross/net output and factor input has arose as the optimal concept for comparison and identification of crop productivity levels either in terms value of output per hectare, per agricultural worker and persons supporting capacity i.e., nutritional levels 'in 'time' or in 'space'. Therefore, it has been attempted to compute productivity levels both in time and space by different angles i.e., yield index basis, in terms of nutrition available per person in relation to cropped land (Standard Nutrition Unit), output per hectare in terms of prevailing prices and output per agricultural worker engaged in farming for three different points of time 1950-51, 1960-61 and 1970-71. An attempt has also been made to develop an input output relationship considering a number of independent variables (inputs), which may cause variations in field productivity (output) in terms of Standard Nutrition Unit). The analysis has yielded significant results for conclusion and suggestions.

The work comprises three parts. The first describes the physical setting of Uttar Pradesh and consists of three chapters namely, structure and relief, climate and soils. Part II attempts to give an account on the concepts and methodological frame for productivity measurement in agriculture in the Chapters IV and V respectively. The Chapter VI under Part III, the analytical frame of this thesis describes the general agricultural conditions i.e., the problems and prospects regarding to agriculture in the State. The Chapter VII deals with the regional differences in food crops productivity, their extents of variation and growth dimensions in different parts assessed through different productivity evaluating methods in Uttar Pradesh. The Chapter VIII examines the major sources of irrigation, extent and intensity of area under irrigation in each district. The description of different resources utilized in agriculture is given in Chapter IX which embodied broadly the area planted under high-yielding varieties programme, distribution and consumption levels of fertilizers, use of farm implements and machinery and advancement of agricultural credit to the farmers. To establish cause and effect i.e., input output type of relationship has been attempted in Chapter XI.

The sources of information available to the writer to undertake this work may be grouped under two broad head: (a) published books, reports and articles, and (b) statistical records (published and unpublished) of various State's Government Departments, especially the Directorate of Agriculture, Chief Engineer of Irrigation, Directorate of Planning, Secretary, Board of Revenue, Office of the Agricultural Census, and Registrar, Co-operative Banks.

At the first instance, I wish to express my deep sense of gratitude to Professor Mohammad Shafi, Head Department of Geography and (Ex.) Vice-Chancellor, Aligarh Muslim University, Aligarh for his valuable and inspiring supervision despite his pre-occupations in the preparation of present work. My thanks are also due to Professor Mohammad Anas and Professor S.M. Rafiullah for their comments and criticisms which I received for precise expression and proper documentation. I have a

deep sense of obligation also towards other members of the staff of Geography Department for their valuable co-operation and help. I would like to record my sincere thanks to Mr. Wasim Abbas, Lecturer, Z.H.College of Science and Technology, A.M.U. Aligarh for his valuable suggestions on the major parts of statistical analysis of the thesis.

I would like to record my sincere thanks to the Librarian of the Indian Agricultural Research Institute, New Delhi, and his staff members expecially of Mr. Abu Shoeb Ahsan for their ungrudging help and co-operation. I have a deep sense of obligation towards the Librarian and the staff of Library, Directorate of Economics and Statistics, and of Library, Indian Council of Agricultural Research, Krishi Bhawan, New Delhi, where I had an opportunity of consulting some recent literature on the problem. For similar reasons I am indebted to the Director and the staff of the State Agriculture Department, Lucknow, Chief Engineer Irrigation, Secretary, Board of Revenue, Director of Planning, Office of the Agricultural Census, Registrar, Co-operative Banks, Sugarcane Commissioner, U.P. and Director, Under Ground Water Investigation Organization, Lucknow who allowed me to get first hand informations required for the present work.

I am equally grateful to my colleagues Messers Jamil Ahmad Khan, Azizur Rehman Khan, Gulsher Ali , Farasat Ali Siddiqui, Mohd. Mazhar Ali Khan, Abu Saad, and Mohd. Javed.

I would very much like to thank Drs. M. Irshad Husain, and Mohd. Siddique of Department of Geography for their valuable help rendered during the preparation of this work. I am also grateful to Dr. Azhar Amin Nomani and Mr. Iqrar Ahmad Khan (Research Scholar) in the Department of Chemistry, A.M.U. Aligarh for their kind co-operation which I received from time to time.

It will be in fitness of things to thank Messers Ch. Mazhar Ali Khan, Najmul Huda Farooqui, Iqbal Ahmad of the Geography Department and Mr. Zahoor Ali Khan of History Department, A.M.U., Aligarh for their cartographic assistance which they gave on the maps accompanying this thesis. My thanks are also due to Mr. Rais Ahmad Qureshi for his help for xeroxing some of the maps and diagrams.

Indeed, I am very much grateful to my parents who have always been a great source of inspiration for my academic pursuits. My thanks are also due, to my wife who very often spared me for research from homely affairs.

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August, 1980 Hifzur Rehman

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INTRODUCTION

In an agricultural country the measurement of agricultural productivity serves a good indicator for planning the allocation of resources so that production efficiency is improved and output is increased in a substantial manner. Often an under-developed economy of a certain region is characterised by a low level of productivity in agriculture. The measurement of agricultural productivity add our knowledge by (i) serving as barometers of agricultural progress, (ii) serving a guide to adjust resources within the regional frame, (iii) providing a framework for formulating and evaluating agricultural policy, and (iv) indicating problem areas that need further research. But the final objective behind the assessment of agricultural productivity is to find ways of increasing output per unit of input and of attaining desirable interfarm transfers of production resources, thereby providing the means for raising our standard of living. Considering the rate of agricultural growth we must be able to measure it, and for formulating effective policies, it would be necessary to assess existing levels, their past trends (growth patterns) and future prospects. It is worthwhile that agricultural productivity should be examined on a regional and intra-regional basis in order to assess variations in time and space, and to suggest imperative measures to formulate plans for different macro as well as micro regions on the basis of past and prevailing realistic conditions. In the absence of such assessments, planning would be haphazard and possibly more developed regions might receive a greater share in the resource allocations whereas, the less developed regions which in fact should receive much greater attention, may lag behind.

Recently the importance of such task was emphasised by the International Geographical Union by establishing the Commission on World Food Problems and Agricultural Productivity at the International Geographical Congress in Moscow in August, 1976. The proposals before commission cover five broad topics.[1]

1. "Assessment of the natural conditions of agricultural development, treated either as resource complaxes to be used for food production-leading to conclusions as to their better use, conservation and improvement, or as obstacles hampering agricultural development-leading to conclusions as to the elimination of these

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1. Agriculture and Food Supply in Developing Countries (ed. J.T., Coppock), Published for the Commission on World Food Problems and Agricultural Productivity of the Internation Geographical Union, Department of Geography, University of Edinburg, 1979, p.1.

obstacles, including assessment of the transformation of the agricultural potential of various environments.

2. Assessment of the management of natural conditions and resources by different agricultural systems, using various inputs of labour and capital technology and equipment-leading to conclusions as to the rationalisation and improvement of such management by overcoming various natural, technical, economic, social and cultural obstacles.

3. Assessment of the actual agricultural productivity of various types of agriculture in relation to their production potentialities and food demand-leading to conclusions as to the ways of raising productivity of land or labour and commercial output of the existing types by making use of unused resources or, it is impossible, by the transformation of the present types of agriculture into, more productive ones.

4. Assessment of the present output and potentialities of non-agricultural food products-leading to conclusions about the possible extension of their use.

5. Assessment of the present storage, transport and marketing of food products and their impact on food production-leading to conclusions as to their rearrangement or improvement to meet the demands of world population".

These were the considerations which led the writer to determine food crop productivity in each of the forty-eight administrative districts of Uttar Pradesh (Plain portion), considering all the food crops which covered an area of about 20.50 million hectares (92.46 per cent) of the total cropped area of the State (1970-71). The district has been taken into account as the unit of study.

Uttar Pradesh is one of the largest and most compact States of the Republic of India. It has a length of about 650 km. from east to west and 240 km. from north to south, and covers an area of 2,94,463 sq. km. of which 48,034 sq. km. (16.30 per cent) is under hilly tract in the north, and the remaining 2,46,429 sq. km. is a plain portion and accounts for 83.70 per cent. The proportion of it to the total area of country as a whole accounts for nearly 9 per cent.

It has rather well-marked natural frontiers on the north and northeast, where it is joined by Tibet and Nepal respectively. On the northwest, west, southwest and east it is seperated from the States of Himachal Pradesh, Haryana, Delhi, Rajasthan, Madhya Pradesh and Bihar. On the northeast however, the boundaries with Nepal are partly natural and partly artificial. On the south, boundaries with Madhya Pradesh are not only artificial but also irregular on account of the intrusion of the Vindhyan hills on to the plains of the River Yamuna.

The State lies between north latitudes 23°52' and 31°18', and east 77°3' and 84°39'. It is bounded on the north by the Himalaya mountains and by the southern watersheds of the River Sutlaj and its tributaries, and of Tibet. On the northeast the boundary is formed by the River Kali, which seperates its from western Nepal. Further northeastwards, the district of Pilibhit, Kheri, Bahraich, Gonda, Basti and Gorakhpur form a common boundary with Nepal. On the east and southeast the State borders on the districts of Bihar, viz., Champaran, Saran, Shahbad and Palamau, while on the south it adjoins the districts of Madhya Pradesh, viz., Surguja, Sidhi, Rewa, Satna, Panna, Chhatarpur, Tikamgarh and Saugor. On the southwest the State is bordered by the districts of Guna, Shivpuri, Datia, Bhind and Morena (all in Madhya Pradesh) and the Bharatpur district of Rajasthan. On the west the boundary is formed by River Yamuna and the Delhi State, the adjoining districts being Gurgaon, Rohtak, Karnal and Ambala (all in Haryana). On the northwest the State shares a common boundary with

Himachal Pradesh and its districts of Sirmur, Mahasu and Kinnaur.

In terms of natural features The River Kali and Mohan partly form the northeastern boundary; the Gandak, Ghaghara, Ganga and Karmnasa form part of the eastern and southeastern boundaries; the Dhasan forms part of the southwestern boundary; the Yamuna forms part of the western boundary and the Tons forms part of the northwestern boundary. Similarly, the Himalayas form the northern, and the Dundwa range forms for a few distance the boundary with Nepal. The rest of the southern and northeastern boundaries are mostly artificial and irregular.

For the administrative purposes the State has been divided into fifty-four districts (Fig.1) and they are grouped into eleven commissioneries[2] namely, Meerut, Agra, Rohilkhand, Allahabad, Jhansi, Varanasi, Gorakhpur, Lucknow, Faizabad, Garhwal and Kumaon. (Appendix I). Each commissionery comprises at the most five to seven districts to administer, Excluding the commissioneries of Garhwal and Kumaon (comprising the districts of Chamoli, Garhwal, Tehri-Garhwal and Uttar Kashi under

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2. Census of India 1971, Uttar Pradesh, Part II A. General Population Table, Series 21.

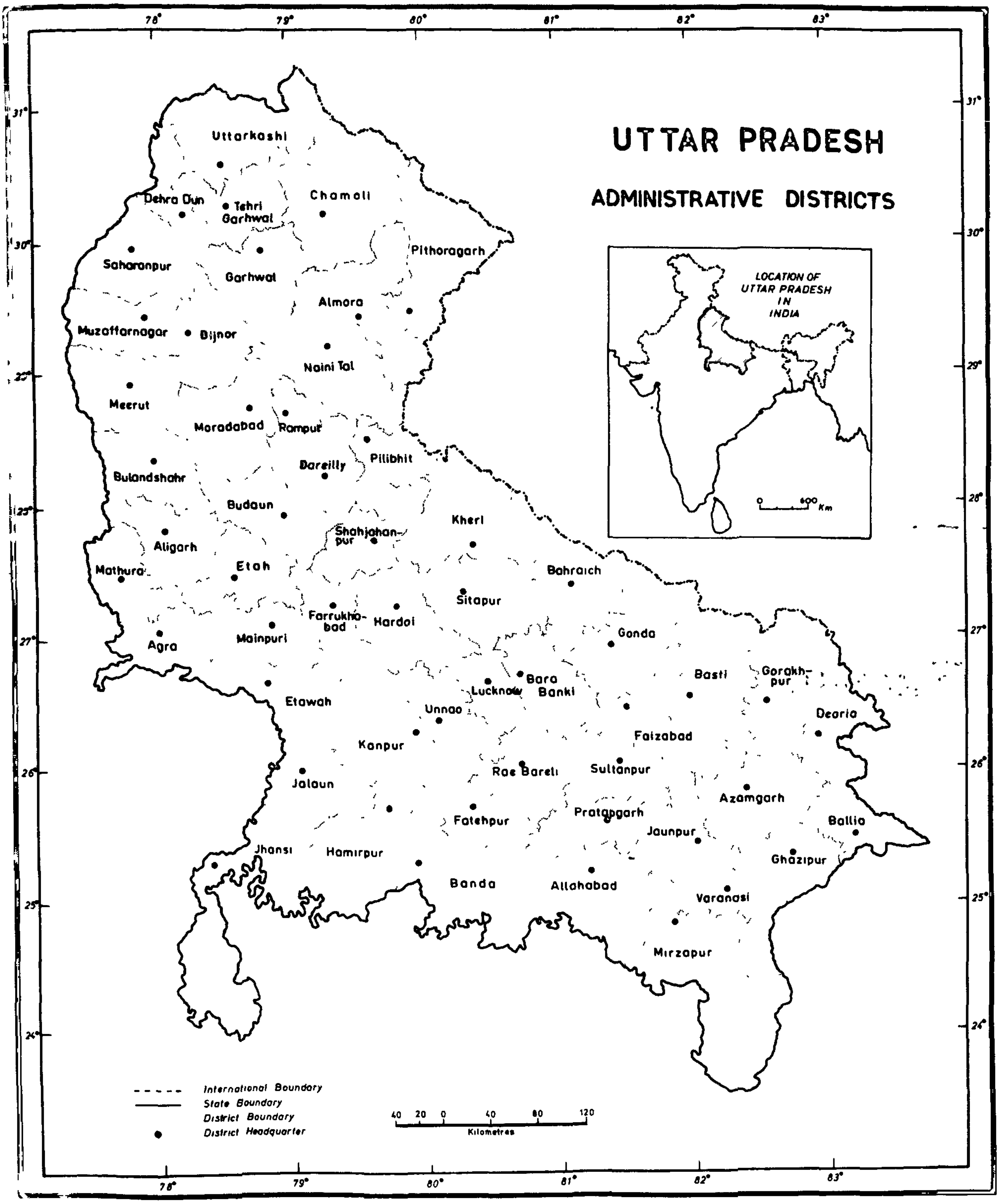
UTTAR PRADESH
ADMINISTRATIVE DISTRICTS
LOCATION OF UTTAR PRADESH IN INDIA
Uttarkashi
Dehra Dun
Tehri Garhwal
Chamoli
Saharanpur
Garhwal
Pithoragarh
Almora
Muzaffarnagar
Bijnor
Naini Tal
Meerut
Moradabad
Rampur
Pilibhit
Bulandshahr
Bareilly
Budaun
Kheri
Aligarh
Shahjahanpur
Mathura
Etah
Bahraich
Sitapur
Farrukhabad
Hardoi
Agra
Mainpuri
Gonda
Basti
Gorakhpur
Lucknow
Bara Banki
Etawah
Unnao
Deoria
Faizabad
Kanpur
Rae Bareli
Sultanpur
Jalaun
Azamgarh
Pratapgarh
Fatehpur
Ballia
Jaunpur
Jhansi
Hamirpur
Ghazipur
Banda
Allahabad
Varanasi
Mirzapur
International Boundary
State Boundary
District Boundary
District Headquarter
Kilometres

FIG. I

Garhwal), and Almora, Pithoragarh and Naini Tal under Kumaon) which cover an area of about 27,000 (9.16 per cent) and 21,000 sq. km (7.14 per cent) respectively of the State, the other commissioneries of the plain portion accounts their aggregate share as 83.70 per cent.

The total population during 1971 census was estimated 88.73 million persons with a density 300 persons per sq. km.

The general slope of the plain is from northwest to northeast with the result the all the rivers rising in the Himalayan mountains, except the right-bank tributories of River Yamuna flow from west to east. The River Ganga divides the plain into two parts by traversing from one end to another.

PART I

THE SETTING

CHAPTER I

STRUCTURE AND RELIEF

The State of Uttar Pradesh forms part of the Indo-Gangetic plain, which lies between norther Gondwana land of peninsular India in the south, and the recently built Himalayan chain of mountains in the north. The plain is 400 km. broad at the most, and about 2400 km. long. But the Gangetic trough is only 1920 km. long.

The north Indian plain consists of the alluvium deposited through geological ages by great Himalayan rivers. The nature of the detritus of various sizes from big boulders to silt and clay, the management of the bedding and the general form of the surface is due to sedimentation laid down in generally inclined layers.[1] Which are the principal types of river deposits.[2] The extensive deposits of very young age are the stratified alluvial accumulation. The Gangetic trough, a cynclinorial depression between peninsular India and the southern front of Himalayas is of post-tertiary formation and filled up by Pleistocene alluviation.[3]

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1. Geikie, J., Earth Sculpture (London, 1898), pp.40-41.
2. Chamberlain, T.C. and Solisbury, R.D., Geology (London, 1909), p.181.
3. Oldham, R.D., Burrard, S.G., and Glennie, E.A., Cited by Wadia, D.N., "The Structure and the North Indian Foreland", Calcutta Geographical Review, Vol.II, No.1, 1938, p.38.

The great Austrian geologist Eduard Suess, holds that it is a 'fore-deep formed in front of the resistant mass of the peninsula when the Tethyan sediments were thrust southward and compressed against them.[4] Burrad, holds the view, that the north India plains represent a rift valley bounded by parallel faults on either side with a maximum downthrow of twenty miles.[5] The Indian geologists have not accepted this view, on the origin of Indo-Gangetic depression,[6] because it has few geological and geo-physical observations.[7] A third, and more recent view regards this region as a sag in the crust formed between the northward drifting Indian continent and the comparatively soft sediments accumulated in the Tethyan basin, when the latter were crumpled up and lifted up into a mountain system. The dynamical effect of either the first or the third view would appear to be the same. The depression perhaps, began to form in the upper Eocene and attained its greatest development during the third Himalayan upheaval in middle Miocene. Since then, it has been gradually filled up by sediments to form a levelled

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4. Krishnan, M.S., Geology of India and Burma, (Madras, 1956), p.529.
5. Burrard, S.G., "On the Origin of Himalaya Mountains, Professional Paper No.12, Geological Survey of India (Calcutta, 1912), p.11.
6. Hayder, D. (1913), and Oldham, R.D. (1917), Cited by Wadia, D.N., Geology of India (London,1949), p.4.
7. Wadia, D.N., and Auder, J.B., Geology and Structure of North India, Memoirs of the Geological Survey of India, Vol.73, (Delhi, 1939), p.134.

plain with a very gentle slope.[8] Geological and geodetic data appear to support the view of the northward drift of the Indian continent and is more acceptable.[9]

E.H. Pascoe, and G.E. Pilgrim, advocate that the Siwaliks were laid down in the flood plains of a single river, the Indobraham or Siwalik river, which rose in Assam and followed the present line of distribution of these deposits. But, Krishnan and Aiyangar discuss this question and show, that the available evidence points to the basin of deposition being a continuous lagoon or fore-deep formed in front of the Himalayan range. It is almost certain, that Siwaliks extend down for several miles underneath the alluvial cover of the Indus and Ganga valleys.[10] On the basis of characteristics of Gondwana rocks found on the northern rims of the alluvial belt of the plain, Wadia and Auden, maintain that the Archaean gneiss, and the peninsular rocks are continuous inside the plain. The continued loading of this belt by sedimentation since the first uplift of the Himalayan mountains may have accentuated the sinking of the archaean floor, but as the process of sedimentation kept pace with that of depression,

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8. Krishnan, M.S., Geology of India and Burma, op. cit., p.529.
9. idem, Introduction to the Geology of India, (Madras, 1944), p.19.
10. Krishnan, M.S., Geology of India and Burma, op. cit., pp.502-3.

there arose the great plain of India. At the same time, there was a great southward shift of the basin with each fresh pulse of the uplift.[11]

The postulation of de Terra (1933-34), that the successive overlaps of younger over older beds from the Ganga Delta to the northwest of Punjab points to a great tilted syncline along which any master stream originally flowed to the southeast has its own difficulties to be accepted.[12]

The sunkin basin or the depression in the crust stretching from Sind to Assam of considerable depth is believed to have been created as a complementary depression to the elevation of the Himalaya. There were gulfs, stretching inland far to the north along the present valleys of the Indus and the Ganga, gulfs of Sind and Assam. Its filling up by the sediments, silt clay, sand, and gravel brought down from the newly upheaved Himalayas is most notable event of sub-recent times. The Indo-Gangetic alluvium contains 'a drift soil'.[13]

Beneath the alluvium of the Gangetic plains, Tertiary strata conceals, what lies below it? However, structural

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11. ibid., p.502.
12. Spate, O.H.K., India and Pakistan (London, 1954),p.33.
13. Wadia, D.N., et al., "Introductory Note on Geological Foundation of the Soils of India", Agriculture and Livestock in India, Vol. VI, Part I, Imperial Council of Agricultural Research, Delhi, 1936, p.77.

events determined sedimentation and of course, no solid rock at any depth of drilling in the north Indian plain has been discovered, and the presence of 'only the sand washed down by Himalayan rivers through course of geologic times from the summit of Himalayas' reveals the geological part played by the Himalayan rivers in the formation of the north Indian plains.[14]

The maximum depth of the alluvium is not ascertained. Some borings have been put down in the alluvial deposits to a depth of around 700 m. for tapping water.[15] Tho bore hole at Lucknow in Uttar Pradesh, is only about 400 m. which has not touched the rock bottom.[16] On tho basis of geodetic data Oldham, finds the depth of Gangetic trough to be 4,600 to 7,000 m. towards its northern edge.[17] Cowle, while criticising the above findings postulated even higher figures from the same data.[18] Recent calculations from geodetic surveys give much lesser thickness for these lighter deposits resting on the dense Archaean bed-rock,[19] and thus, Glennie,

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14. Hart, H.C., New India's Rivers (Calcutta,1956),p.12.
15. Krishnan, M.S., Introduction to the Geology of India, op. cit., pp.169-70.
16. Krishnan, M.S., Introduction to the Geology of India, op. cit., pp.169-70.
17. Oldham, R.D., The Structure of the Himalayas and of the Gangetic Plain, Memoirs of the Geological Survey of India, Vol.XLII, Part II, Calcutta, 1917, p.82.
18. Cowle, H.M., A Criticism of R.D. Oldham's paper on the 'Structure of the Himalayas and the Gangetic Plain' as eluciated by Geodetic Observations in India, Memoirs of the Geological Survey of India, Professional Paper No.18, Dehra Dun, 1921,p.6.
19. Glennie, E.A., Gravity Anomaties and the Structure of the Earth's Crust - Survey of India, (Dehra Dun, 1932), p.22.

challanged these figures on the basis of new gravity anamolly readings obtained from different stations in the plain, and calculated the maximum depth of alluvium as 1,980 m. The figures calculated by Glennie, conforms with geodetic data though not with geological facts, it can be regarded as reliable, and may will be higher. The sub-montane Indo-Gangetic trough is believed to be 1800-3050 m in depth.[20]

All the borings, that have hitherto been made failed to reach the rocky bottom.[21] However, the deepest part is near to the northern edge than the southern. It becomes gradually shallower towards the peninsular margin. The depth of the alluvium is at a maximum between Delhi and Rajmahal hills.[22]

The alluvial deposists of Uttar Pradesh are classified under two sub-divisions: old and new deposits, known as bangar and khadar respectively. These deposits, in respect of their geological age correspond with the two main divisions of Quartenary era: the Pleistocene and the Recent.

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20. Wadia, D.N., The Geology and Mineral Resources of India (Baroda, 1955), p.51.
21. idem, Geology of India, (London, 1953), pp.283-84.
22. ibid., p.285.

BANGAR

The bangar land occupies the higher ground in Uttar Pradesh, and is not flooded by the rivers during the rains. The bangar alluvium contains the parent material forming the kankar nodules of carbonate of lime. These kankars found in abundance, are the irregular concentration of impure calcareous matter. This older alluvium is distinguished by the nodular segregations of carbonate of lime[23] or calcareous concretions which are abundant in the drier regions.[24] The bangar land is characterised by patches of saline and alkaline efflorescences, which are the result of gentle slope of the land and the composition of the alluvium.[25] The bangar land, above the flood level generally possesses, clay and sodium clay as dominent constituent reacting with kankar (nodul) which liberates sodium carbonate and is turned into calcium clay.[26]

The bangar as a rule occupies higher grounds than the recent khadar.[27] Most of the kankar occurrence consists of irregular small pieces of varying diameters from one

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23. Rastall, R.H., Agricultural Geology, Cambridge Geological Series, 1922, p.100.
24. ibid., p.160.
25. Auden, J.B. and Roy, P.C., Report on, Sodium Salt in Reh Soils in the U.P., Professional Paper No.1, Records of the Geological Survey of India (Calcutta, 1942), p.3.
26. Spate, O.H.K., op. cit., p.34.
27. Krishnan, M.S., Geology of India and Burma, op. cit., p.34.

centimetre to ten centemetres or more and it is of all shapes and sizes from small grains to big lumps.[28] Bangar of the Ganga valley is rich in nodules of dark colour. The vertical distribution of kankar beds is in well defined layers varying from pure sand beds to those composed of heavy clays of impervious layers, continuous or intermittent within the soil.[29]

The formation of kankar concretions is due to segregation of the calcareous material of the alluvial deposits into lumps or nodules some what like the formation of flint in limestone.[30] These kankar nodules, and the calcareous beds are said to have been deposited from water containing a solution of carbonate of lime, derived from the older rocks of various kinds or else from fragments of limestone contained in the alluvium.

In some places of upland bangar alluvium, the kankar concretions outcrops cover wide areas at the surface, while in other places they are found at a depth as great as ten to fifteen metres.

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28. Wadia, D.N., et al., op. cit., p.78.
29. Wadia, D.N., Geology of India, op. cit., p.287.
30. Krishnan, M.S., Introduction to the Geology of India (Madras, 1956), p.529.

KHADAR

The newer alluvium of Gangetic trough, called *khadar*, corresponds with the recent geological age of Quarternary era. The *khadar*, light coloured, sandy and poor in calcareous matter is found generally in the river valleys. The animal remains in the *khadar* are mostly identical with living species.[31] The *khadar* areas in the Gangetic plain are like 'figures' along the main stream and their sub-parallel tributories such as, the Ramganga and Gomti.[32] The rivers annually refresh the area by bringing down the new silt, particularly in the main flood plains, which they bring from the northern mountains. Nevertheless, the *kankar* areas are of lower ground than those of *bangar*.

The prevailing soil of *khadar* is sandy. It is almost pure (sand) on the banks of river Ganga but, as one proceeds away from the river, sandy character of the soil gradually decreases and is replaced by the fine silt. This fine silt called *panga*, is most fertile and laid down by the river after the flood water is receded. But, the area inundated by it is generally within the range of two km. from each of the banks.

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31. Spate, O.H.K., op. cit., p.497.
32. Wadia, D.N., *Geology of India*, op. cit., p.251.

Khadar lands owe their origin to the *bangar* lands through the erosive action of the rivers. The remanants of *bangar* lands are subjected to erosion by the changes in the direction of the meandering river channels.[33] The *khadar* areas contain lenticular beds of sand, gravel and peat beds. But, these contain neither *kankar* or reh salts. The lenses of sand are gravel, graded imperceptibily into recent alluvium and are good reservoirs of underground water.

There are various names of *khadar* soils in different parts of the State, although they are sandy with sandy silt of varying consistency. The *khapat*, *patka*, *bela* and *kanp* are some of the local names of *khadar* soils. In some places, which are marshy lands and lie some distance from the *khadar* heavy matiyar clays are found, which are quite suitable for cultivation.

The layers of the sub-soils of the *khadar* tract are generally uniform in texture unlike those of *bangar* soils. But, as the sub-soil water level is relatively high, these lands need no irrigation. The amount of nitrogen and organic matter in *khadar* soil is derived from the silt of the flood water, and needs renewal every year for purposes of cultivation, while in *bangar* soil they are comparatively more durable.

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33. Hilgard, E.W., *Soils* (New York, 1919), p.15.

The *khadar* is deficient in calcareous constituents but is entirely protected from injurious salts of soda and magnesia accumulation and form alkaline or saline efflorescences which reduces fertility and make the soil alkaline, while all of these injurious matters may be present in *bangar* tracts. Unlike the *khadar* areas saline and alkaline soils are found in areas of poor drainage with high evaporation. It is remarkable, that the position of the *khadar* tracts shifts with the shifting of river channels, and those *khadar* tracts which thus become inaccessible to river inundation are converted into *bhur* tracts, as these areas are deprived of annual deposition of fine silt, 'panga', the *bhur* soil then cannot efficiently grow agricultural crops, and are only confined to typical crops like melons and water-melons.

The continued productivity of (khadar) alluvial soils is moreover assured by the deposition during overflows of fresh soil material brought down from the head waters of the stream. Therefore, the *khadar* soils consist a mixture of fine sand and silt which possess usually very favourable physical composition and adequate moisture.

DRAINAGE

The general slop of the land in Uttar Pradesh is from northwest to northeast. With the exception of right-bank tributories of the Yamuna, almost all other rivers of the State rising in the Himalayas flow from west to east (Fig.2). The Ganga traverses the State from one end to the another and divide it into two parts. The region which lies to the west and south of the river is much smaller than that which is to the north and east. The western region consists of the tract which lies between the Ganga and Yamuna, while the southern part includes the lower Doab and the area lies to the southwest of the Yamuna. A portion of the southern tract, however, lies to the east of Allahabad and includes the whole of Mirzapur district, and part of Allahabad, Varanasi, and Ghazipur districts. The Hindan river which flows through the northern Doab carries the drainage from the Siwaliks and the plain below, and falls in the Yamuna in the Bulandshahr district. In the northern Doab, the Ganga receives a number of tributories. While in the south, the Yamuna is joined on its right bank by the Chambal, which drains parts of Madhya Pradesh and Rajasthan. It also receives Kuwari, Sindh, Pahuj, Betwa, Dhasan, Ken, Garara, Baghein, Paisuri and Ohan. These rivers wash the northern slopes of the Vindhyan Mountains and flow through Bundelkhand before

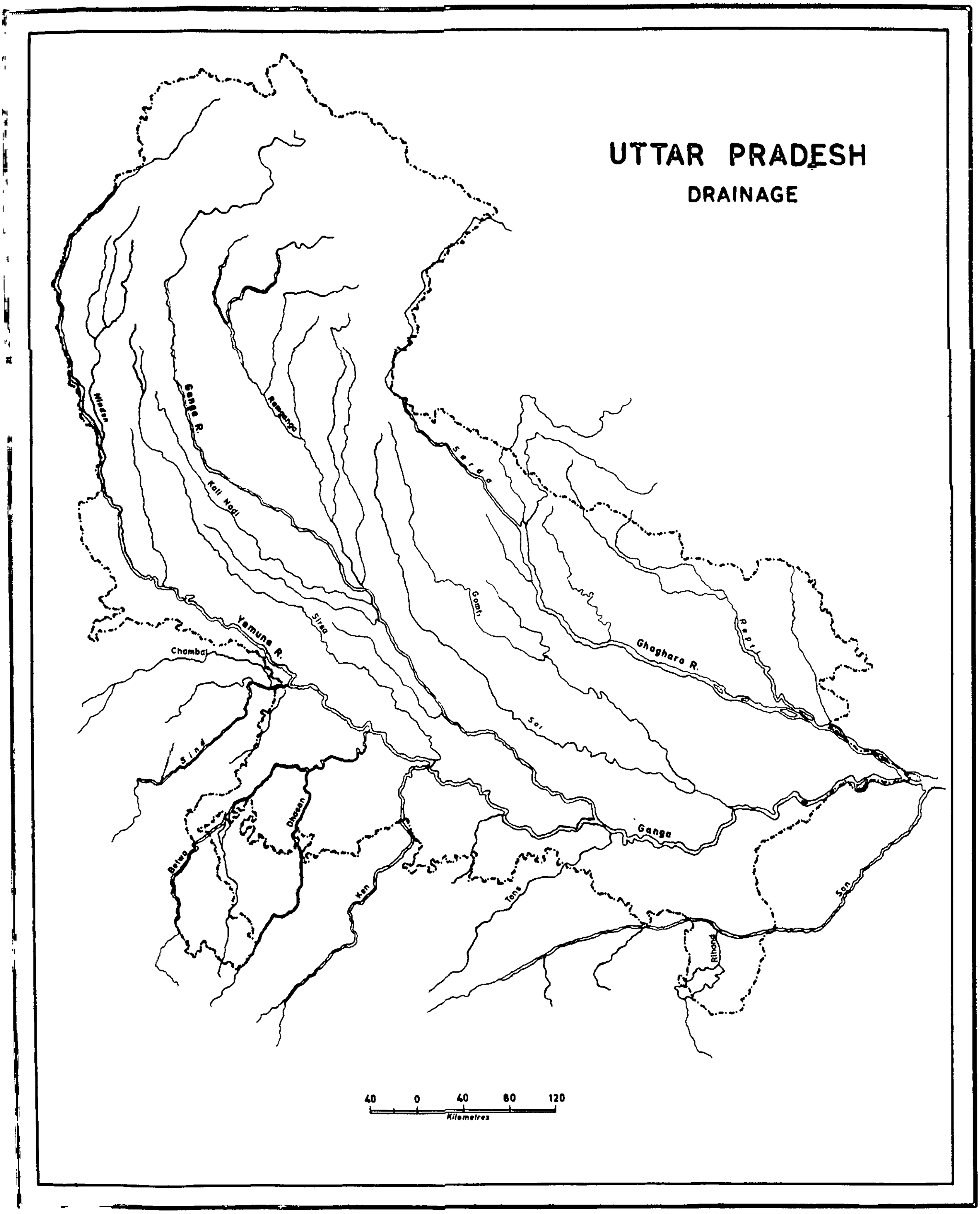
UTTAR PRADESH
DRAINAGE
Ganga R.
Ramganga
Sarda
Kali Nadi
Gomti
Sirsa
Yamuna R.
Chambal
Ghaghara R.
Rapti
Sai
Sind
Dhasan
Betwa
Ganga
Ken
Tons
Son
Rihand
40 0 40 80 120
Kilometres

FIG. 2

joining the Yamuna. Further east, the Karamnasa River, which forms the boundary between Uttar Pradesh and Bihar, flows through the districts of Mirzapur and Varanasi to join the Ganga in the Ghazipur district. The Son River is another tributory of the Ganga and it traverses the Mirzapur district from west to east.

To the east of the Ganga there are three main rivers, viz., the Ramganga, Gomti and Ghaghara. The Ramganga and the Ghaghara rise in the Himalayas and join the Ganga on its left bank in the district of Farrukhabad and Saran (Bihar) respectively. The Gomti rises in the Tarai and flowing parallel to the Ganga and Ghaghara has a confluence with the Ganga in the Ghazipur district. The Gandak, which rises in the Himalayas, only touches the eastern boundary of Uttar Pradesh. A number of cannals have been tapped from these rivers and under the Five Year Plans a number of multipurpose dams have been constructed by which the face of agriculture in Uttar Pradesh is changing day by day.

The Ganga: The Ganga rises in the Gomukhi Glacier of the Himalayas in the Uttar Kashi district of Uttar Pradesh and flows southwards under the name of Bhagirathi till it meets at Devaprayag with its first main tributory, Alaknanda, from the east. From here the river is known as the Ganga. After a journey of 288 km. from its source, the river descends to the plain at Hardwar. Following the general slope of the country, it flows southeastwards acros the whole length of Uttar Pradesh leaving it in the extreme east of the Ballia district. The Ganga carries all the drainage not only of Uttar Pradesh but also of the whole of northern India and discharges it into the Bay of Bengal.

The main tributories of Ganga are the Ramganga, Yamuna, Tons, Gomti and Ghaghara. The Yamuna and Tons join the Ganga on its right bank at Allahabad, and others meet it on its left bank. A number of cities, cultural and educational centres have developed along the course of the Ganga. Some of the more important places are Badrinath, Kedarnath, Joshimath, Karnaprayag, Rudraprayag, Srinagar, Devaprayag, Harishikesh, Hardwar, Garhmuktesar, Anupshahr, Farrukhabad, Kannauj, Kanpur, Manipur, Kara, Allahabad, Mirzapur, Chunar, Varanasi, Ghazipur and Ballia.

The Yamuna: Although the Yamuna is a tributary of the Ganga, it is the second most important river of Uttar Pradesh. It rises from the western side of the snow-clad peak of Bandarpunch (6315.46 metres) in the Uttar Kashi district of Uttar Pradesh. It receives waters from the western side of the Tons which forms a part of the northwestern boundary of Uttar Pradesh, the confluence of the two being between Majri and Haripur. The river than passing through the Siwaliks enters the western plain at Faizabad, and thence flows roughly parallel to the Ganga for 1384 km. to join it at Allahabad. The Yamuna is especially significant because it forms an excellent natural boundary between Uttar Pradesh and Haryana. It enters the Mathura district in the north and passes through the districts of Agra and Etawah. Then, forming the northern boundary of the districts of Jalaun, Hamirpur and Banda, and the southern boundary of the districts of Etawah, Kanpur, Fatehpur, and part of Allahabad it meets the Ganga.

It addition to the Tons, there are a number of other right bank tributories of the Yamuna. The most important ones are the Chambal, Betwa and Ken. The Hindan is the only important left bank tributory and it joins the Yamuna at Bulandshahr. The more important towns on the Yamuna include Kalshi, Vrindavan, Mathura, Gokul, Sikendra, Agra, Firozabad, Etawah, Kalpi, Hamirpur, Kosan and Allahabad. The city of Delhi, too is situated on its bank.

The Ghaghara: The Ghaghara is the next important tributory of the Ganga in Uttar Pradesh. It rises under the name of Karnali from the upper ranges of the Himalayas which form the northern boundary of Nepal. After traversing Nepal longitudenally, it enters in Uttar Pradesh as two seperate streams, viz., Kauriala and Girwa. The Kauriala forms the boundary between the Bahraich and the Kheri districts for a short distance before meeting the Girwa. It flows towards southeast and then to east, thus seperating the districts of Bahraich, Gonda, Basti, Gorakhpur and Deoria from the districts of Kheri, Sitapur, Bara Banki, Faizabad, Azamgarh and Ballia. It joins the Ganga in the Saran district of Bihar. From the extreme southeast of Deoria upto the northeast of Ballia, it forms the boundary between Uttar Pradesh and Bihar. This boundary, however, remains liable to changes on account of the shifting nature of the course of the Ghaghara. The western most tributory of the Ghaghara is the Kali which (since 1814-16, the date when Kumaon came under the British control), forms the entire western boundary of Nepal with Uttar Pradesh.[34] After leaving Nepal, the Kali is known as the Sarda, and in its latter course as the Chanka, and joins the Ghaghara in the west of Sitapur. The Mohan is another tributory of Kauraila which forms the entire northern boundary of the Kheri district with Nepal. The Saju, which rises in the Dhang Range in southern Nepal, flows across the Siwalik and then through northwestern Bahraich to meet the Ghaghara.

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34. Bartholomew, J., The Times Atlas of the World, Vol.II (London, Mid-Century ed., 1959), Plates 29 and 30; Report on the Administration of the North West Provinces for the year 1872-73, p.44.

The Gomti: The Gomti River rises in the Pilibhit district of Uttar Pradesh and flows towards southeast between the Ganga and the Ghaghara. After leaving the Pilibhit district it traverses the Shahjahanpur and the Kheri districts. Then, forming the boundary between the Hardoi and Sitapur districts it enters the Lucknow district in the north, passes by the northern and eastern side of Lucknow city, forms for a short distance the boundary between the Lucknow and Bara Banki districts, crosses the western portion of the Bara Banki district, and forms a short boundary between the Bara Banki and Sultanpur districts. It then passes through the Sultanpur district and before leaving it again forms its southeastern boundary with the Pratapgarh district. Further or, it passes through the Jaunpur district and then forming the boundary between the Jaunpur and Varanasi districts, and Varanasi and Ghazipur districts it joins the Ganga on the Varanasi-Ghazipur border. The largest tributory of the Gomti is the Sai, which meets it in the Jaunpur district. Its other tributories are the smaller streams such as, the Kathna, Sarayan and Kalyan. The first two flowing into the Gomti in the Sitapur district while the third joining it in the Bara Banki district. The most important city on the bank of the Gomti is Lucknow, which is the capital of Uttar Pradesh. Sultanpur and Jaunpur are the other important towns on the banks of this river.

The Ramganga: The Ramganga rises in the Tarai of the Kumaon hills (which lies in the Garhwal district of Uttar Pradesh) and enters the plains in the Bijnor district. It then flows southeastwards through the districts of Bijnor, Moradabad, Rampur and Bareilly. From here it forms boundary between the Bareilly and Budaun districts and also between the Budaun and the Shahjahanpur districts. Then, flowing through the Shahjahanpur and Farrukhabad districts it passes through the Hardoi district. In this way it flows for about 595 km. before it joins the Ganga near Kannauj in the Farrukhabad district. This river very often changes its course, especially during the rainy season. Moradabad is the principal city situated on its bank.

The Sai: It is the most important tributary of the Gomti joining on its right bank. It rises in the Hardoi district and traverses the districts of Rae Bareli and Pratapgarh and forms the boundary between the Lucknow and Unnao districts. Subsequently it flows through Jaunpur district before joining the Gomti about 60 km. upstream of the confluence of the latter with the Ganga. The Sai river has a drainage area of 11,115 sq. km.

The Sarda: It is formed by two streams the Kuthiayankti and the Kalapani near the Indo-Tibetan border at an elevation of 5,250 metres. The river flows in a southwesterly direction for some distance forming the boundary between Indian and Nepal. In this reach it receives the Dhauli Ganga, the Khoprang, the Sarju and the Ladhiya on its right and the Chumlia on its left bank. It debounches into the plains of Uttar Pradesh after passing through a series of rapids.

Entering the plains, the Sarda continues to form the boundary between India and Nepal for a short distance flowing in a boulder bed. Thereafter, it flows in a southeasterly direction through the district of Pilibhit in a tortous and constantly changing course. During high floods large areas are inundated by the waters of the Sarda. One of the most important irrigation systems in Uttar Pradesh, irrigating lands in the Gomti-Ghaghara Doab emanates from this river from the Banbassa head works.

The Rapti: It is another tributory of the Ghaghara to join on its left bank. It rises in the lower ranges of Nepal at an elevation of 3600 m. after flowing through Nepalese territory for a distance of about 150 km., it enters the Bahraich district of the State. It then flows in a southeasterly direction through the districts of Gonda, Basti and Gorakhpur before joining the Ghaghara near Barhaj in the last named district. The Rapti also inundates large territory on both the banks. But flooding is beneficial because of the fine silt left behind which makes the land fertile and productive.

PHYSICAL DIVISIONS

The State of Uttar Pradesh is divided into four broad physical divisions: (i) Montane tract; (ii) Sub-Montane tract; (iii) The Gangetic plain; and (iv) Trans-Yamuna tract (portions of Central Indian Plateau).

I. Montane Tract

The montane tract constitutes the extreme northern part of the State, and comprises the districts of Uttar Kashi, Chamoli, Almora, Garhwal, Tehri Garhwal, and Pithoragarh; Dehra Dun and Naini Tal (in part). In respect of area this tract stands fourth and in respect of population fifth in the State.

This region comprises the Inner and the Outer ranges of Himalayas. The outer ranges of hills rise quickly from the sub-montane tract to a height of 2150 to 2450 m. On the western side, there lies the district of Dehra Dun partly between the Himalayas, and the Siwalik hills for 72 km., extending upto the slopes of both ranges. We notice a gradual change in vegetation, climate and physical features moving towards the hills from the plains. In both Inner and Outer Himalayas hill tops, terraced slopes and river valleys are brought for cultivation. The limitations for agricultural operations seem to be the scarcity of irrigation water, manure and availability of agricultural land. Limited irrigation facilities lead to the cultivation of inferior crop, such as Mandua (small millet) which is grown normally with a great success.

II. Sub-Montane Tract

This region lies between the Ganga and the Sarda rivers and has three distinct portions. First, the tract of Bhabar, which lies immediately below the foot-hills with a strip of land about 32 km. wide in the west and gradually becoming narrower in the east. The word Bhabar means 'porous ground' and in fact during the summer months this tract has little surface drainage. In the rainy season the sub-terranean drainage appears above the boulders and gravel. Secondly, below the Bhabar is a wider strip of land, known as Tarai, a low marshy land infested by tall grasses and scrub and conspicuous by the 'ubiquitous' presence of water. In fact, the bulk of water from the rainfall and small hill-streams loses itself in Bhabar reappears again on the surface in the Tarai. As a result this tract is damp and marshy. The Tarai, particularly in its western part is dotted with springs, marshes, bogs, lakes and'tals' of varying size and dimensions. The rivers Gandak, the Ghaghara, the Gomti, and the Ramganga are traversing the whole region with a number of tributary streams of unstable character. In Tarai, the population is sparsely distributed and having migaratory character due to unhealthy climate and prevalence of malaria.

Thirdly, the other districts of plain partake of the nature of Tarai, more especially in their northern portions. The rainfall is heavy and the streams are numerous. The whole tract looks like a sloping plain. Such types of lands are found in all the districts, viz., Saharanpur, Bijnor, Rampur, Bareilly, Pilibhit, Kheri, Bahraich, Gonda, Basti and Gorakhpur running upto Nepal borders.

III. The Gangetic Plain

More than half of the total area of the State (about 86,041 sq. km.) is included in the great Indo-Gangetic plain. This plain is divided into five sub-regions (Fig.3).

(a) The Ganga-Yamuna Doab

This fertile tract has been enriched by the alluvial deposits of both the rivers, extending nearly upto 832 km. in length and 104 km. in width in the upper part covering an area of about 58,400 km. of the State (Fig.3, III a). It is lying in the form of a trough between Himalayas in the north and the Deccan plateau in the south. The alluvial deposits brought by the Himalayan rivers consist of sediments, silts, and clays with occasional gravel belts.

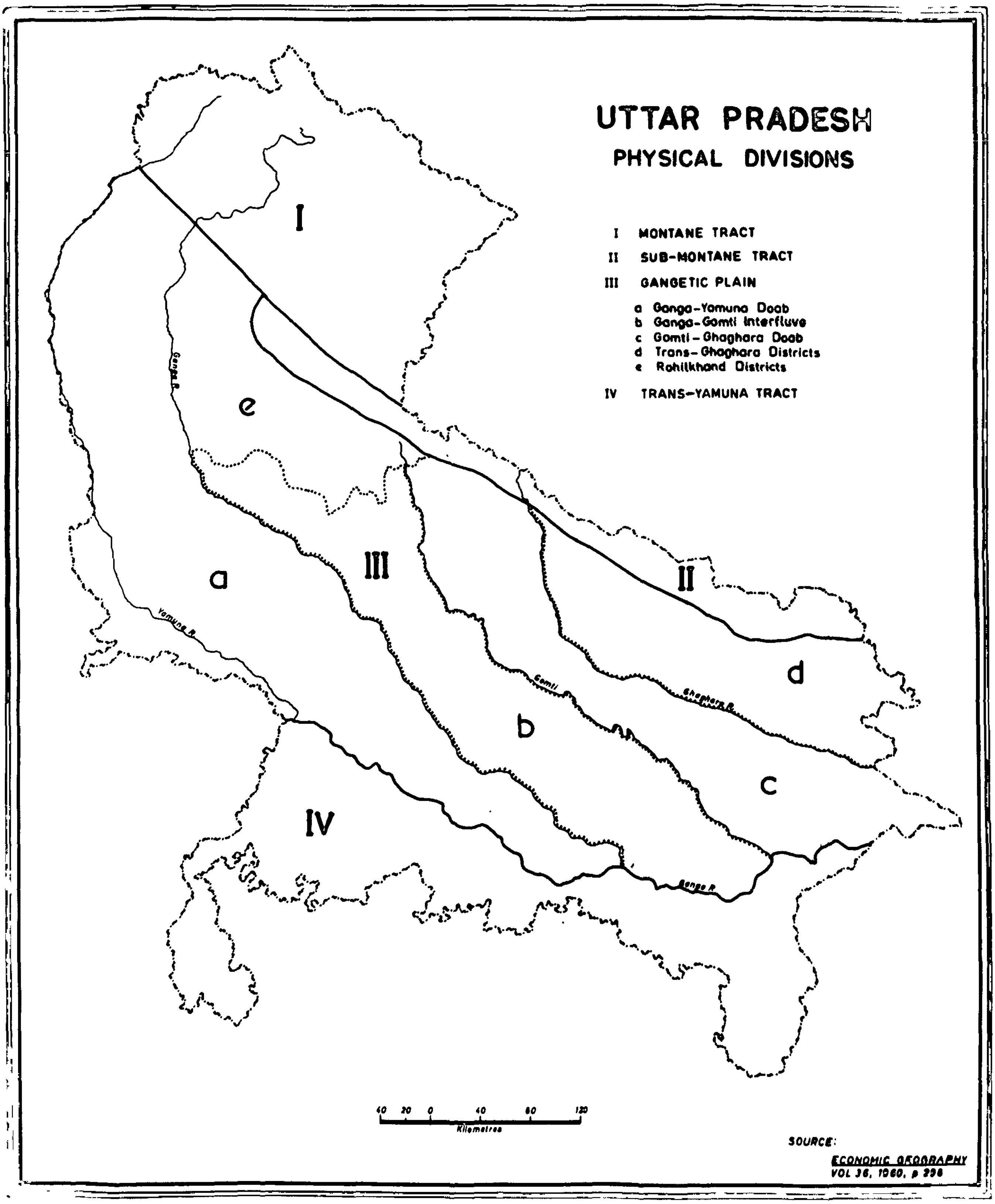
UTTAR PRADESH
PHYSICAL DIVISIONS
I MONTANE TRACT
II SUB-MONTANE TRACT
III GANGETIC PLAIN
a Ganga-Yamuna Doab
b Ganga-Gomti Interfluve
c Gomti-Ghaghara Doab
d Trans-Ghaghara Districts
e Rohilkhand Districts
IV TRANS-YAMUNA TRACT
I
II
III
IV
a
b
c
d
e
Ganga R.
Yamuna R.
Gomti
Ghaghara R.
40 20 0 40 80 120
Kilometres
SOURCE:
ECONOMIC GEOGRAPHY
VOL 36, 1960, p

FIG. 3

The soils of Doab are alluvial and geologically fall into two divisions: the new alluvium or khadar and the old alluvium or bangar. The khadar soils here are found in the narrow flood plains of the rivers, and the bangar soils varies in accordance with their topographic features and drainage.

This part of the State possos the highest agricultural productivity. Most of the districts are more advanced and production per hectare and per person is highest as compared to the rest of the State.

(b) Ganga-Gomti Interfluve

The region lying between the Ganga and the Gomti is less fertile compared to that of Ganga-Yamuna Doab. The reason for this is that most of the area is commanded by the Gomti itself and its tributories which rise from a lake. On account of very gentle gradient of the plain, the Gomti flows in a tortuous course and as a result the command area is dotted with numerous small lakes, which are mostly seasonal in character. During the hot weather season their water is evaporated, but during the wet monsoon months their water over flows and inundates the neighbouring lands resulting in waterlogging. The fertility status of the soil in the Ganga-Gomti Interfluve is generally low because of the fact, that this tract receives less of silt and more of sand during floods.

(c) Gomti-Ghaghara Doab

In the tract between Gomti and Ghaghara the soil deteriorates further, because the Ghaghara brings a huge amount of sand in the wet monsoon, so the commanding areas of this river have a higher percentage of sandy soil. Agricultural practices largely depend on monsoon rainfall. Great variations in agricultural outturns occur due to the variations in the amount of rainfall and the quality of soil.

(d) Trans-Ghaghara Tract

This tract forms the northeastern part of the Gangetic Plain and is a well demarcated physical unit hemmed in between the Himalayas and its Tarai in the north, and the Ganga-Ghaghara Interfluve in the south (Fig.3, III d). The soils of this tract may be grouped under two distinct types, locally known as bhat and bangar. The third type of soil known as dhab occurs nearly on the river banks. The bhat soil which is generally lowlying calcareous, retentive of moisture and does not require much irrigation in the normal years covers the eastern extremity of the tract. Sugarcane is the main crop. These soils are comparatively inferior to those of the Gomti-Ghaghara tract. Irrigation facilities are inadequate and the agricultural operations largely depend on rainfall.

(e) Rohilkhand Tract

The adjoining districts, viz., Bijnor, Moradabad, Rampur, Pilibhit, Budaun, Bareilly and Shajahanpur to Montane tract, are known as Rohilkhand tract (Fig.3,III e). This region of the State derives little benefit from the major river and canal systems of the State. The region is not susceptible to floods and therefore, the soil is poor in its nutrient character. The northern portion of these districts possess climate and natural vegetation similar to that of Tarai region.

IV. Trans-Yamuna Tract

On the southwest and south lies two small tracts belonging to natural divisions of India which differ considerably from the main portions of the State. The four districts of Jalaun, Banda, Hamirpur and Jhansi form part of the Central Indian Plateau. The tract is situated on and below the eastern slopes of the great plateau with a gradual fall from southwest to northeast. The soils are largely rocky and infertile with considerable patches of the richer type known as, 'black soil' which differ entirely from the alluvial soils of the great plain.

Mirzapur, the largest district occupying the southeastern part of the State also forms the part of the plateau. The spring level is low, canal system is not well developed. The tract either suffers from an excess or a deficiency of rainfall, and as a whole ranks agriculturally the poorest and most backward region of the State.

CHAPTER II

CLIMATE

The entire State has tropical monsoon climate, except the Himalayan region where the climate is designated as temperate. It is characterised by a rhythm of seasons which is caused by the south-west and north-east monsoons. The pressure reversal takes place regularly twice in the course of year. At the time of north-east monsoon winds are of continental origin and blow generally from west to east, while during south-west monsoon they are oceanic in origin and blow mostly from east to west. The pressure gradient during the north-east monsoon is quite gentle and the winds are, therefore, weak. During the south-west monsoon the intensive heating of north-west India produces steep gradients owing to which the winds are quite strong. Taking into consideration the nature and directions of winds, they are termed appropriately as dry and wet monsoon respectively.

The two agricultural seasons of <u>kharif</u> and <u>rabi</u> closely follow the dry and the wet monsoons. The dry north-east monsoon extends from November to the middle of June. The first three months record low temperatures, and the last three have high temperatures. The whole period can be divided into two seasons: (i) Cold weather season, and (ii) Hot weather season. The cold weather season extends from November to February, and the hot weather season lasts from March to mid- June. The cold weather season corresponds with the season of <u>rabi</u> crops, while the hot weather season is generally dry and does not permit cultivation until the onset of the south-west monsoon. <u>Zaid</u> crops consisting of melons, water-melons and cucumbers are grow with the help of irrigation. The wet monsoon months of the year i.e., from mid- June to October correspond with the crops of <u>kharif</u> season. Thus the whole year in the State of Uttar Pradesh is divisible into three seperate seasons:[1]

(i) The cold weather season (November to February)
(ii) The hot weather season (March to mid- June)
(iii) The season of rains (mid- June to October)

The Cold Weather Season (November to February)

During the month of November a high pressure belt extends from northwestern India and covers the Indus and

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1. Indian Meteorological Department, has devised a four-fold climatic divisions of the year grouped under the two monsoons as follows:
(a) The season of north-east monsoon:
(i) January and February; cold weather season,
(ii) March to mid- June; hot weather season.
(b) The season of south-west monsoon:
(i) Mid-June to mid-September; season of general rains,
(ii) Mid-September to December; season of retreating monsoon.
These divisions are purely based on the meteorological conditions and do not consider the agricultural seasons of the year. In appreciation of the climatic influence on the agriculture of the area, the writer has followed the common classification of the three seasons correspond with the three agricultural seasons of the year.

Ganga valley and passes through the Bundelkhand tract of the State from northwest to southeast. The prevailing direction of the winds from west to east is usually determined partly by pressure distribution and partly by stretches of the Himalayan relief. The pressure gradients are not steep to produce strong winds, therefore, the breezes are very light in November and December with a velocity of 2.7 km. per hour.[2] But, as the pressure increases in the month of January and February the gradient becomes a little steep, the velocity increases to 3.5 and 4.3 km. per hour in the each respective month.

It will be seen from Figs.4&5 that the mean minimum temperature in the month of November at Roorkee, Aligarh, Bareilly, Jhansi, Allahabad, Gorakhpur and Bahraich[3] ranges between 5°C and 10°C, but the mean maximum temperatures at the above stations ranges between 29°C and 33°C. The month of December records a further decrease both in the mean minimum and maximum temperature. The mean minimum temperature ranges between 2.5°C and 6.5°C. While the mean maximum shows range between 25°C and 27°C. The days in December are less warm, and the nights are cooler than November.

2. Normals of wind speed relate to Jhansi station, Climatological Tables of Observatories in India (New Delhi, 1953), p.122.
3. Seven stations covering different parts of the State have been selected to present the temperature condition of the State. Calculations are based on the sixty years record collected from Indian Meteorological Department, New Delhi.

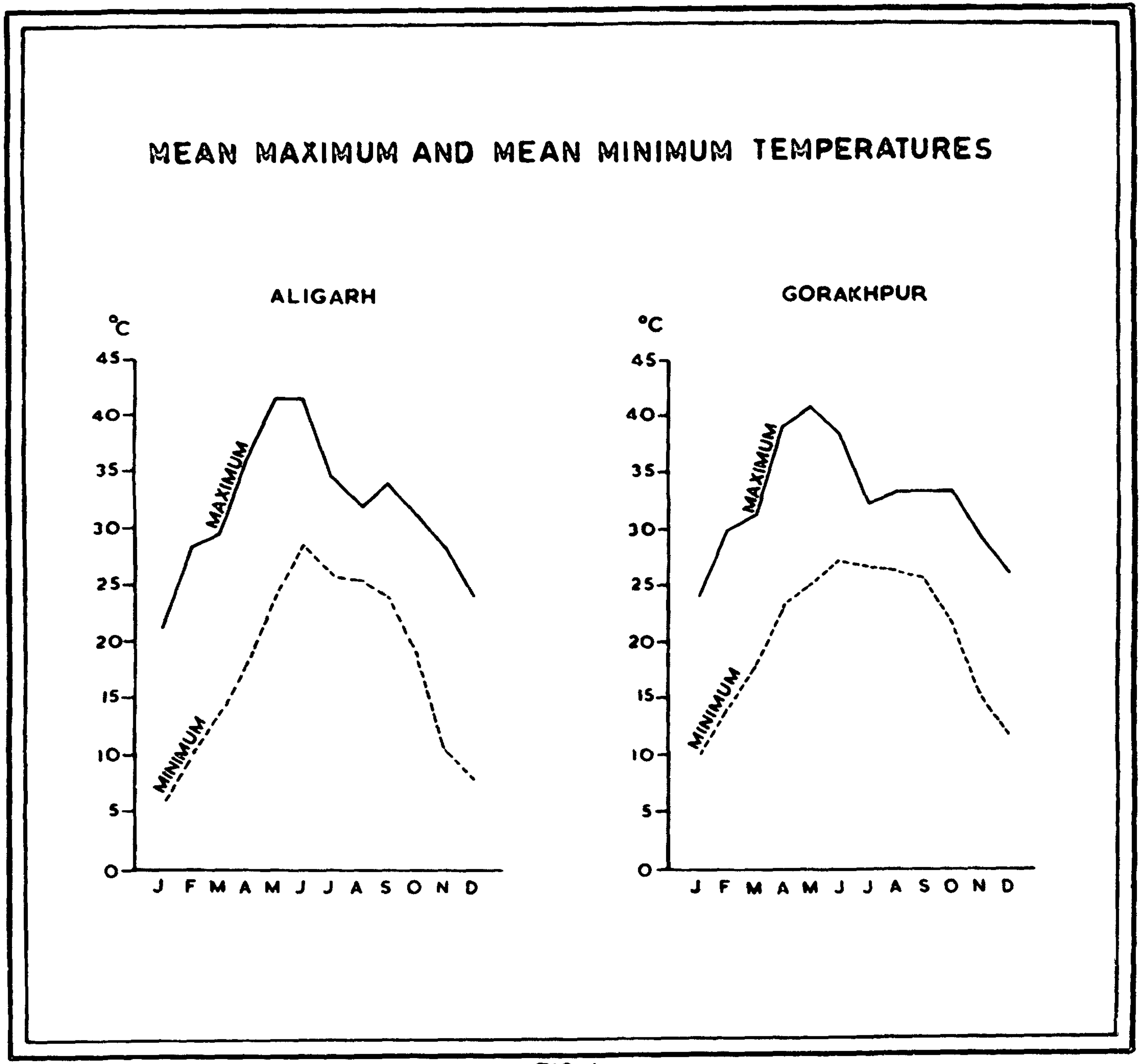
MEAN MAXIMUM AND MEAN MINIMUM TEMPERATURES
ALIGARH
GORAKHPUR
°C
45
40
35
30
25
20
15
10
5
0
MAXIMUM
MINIMUM
J F M A M J J A S O N D

FIG. 4

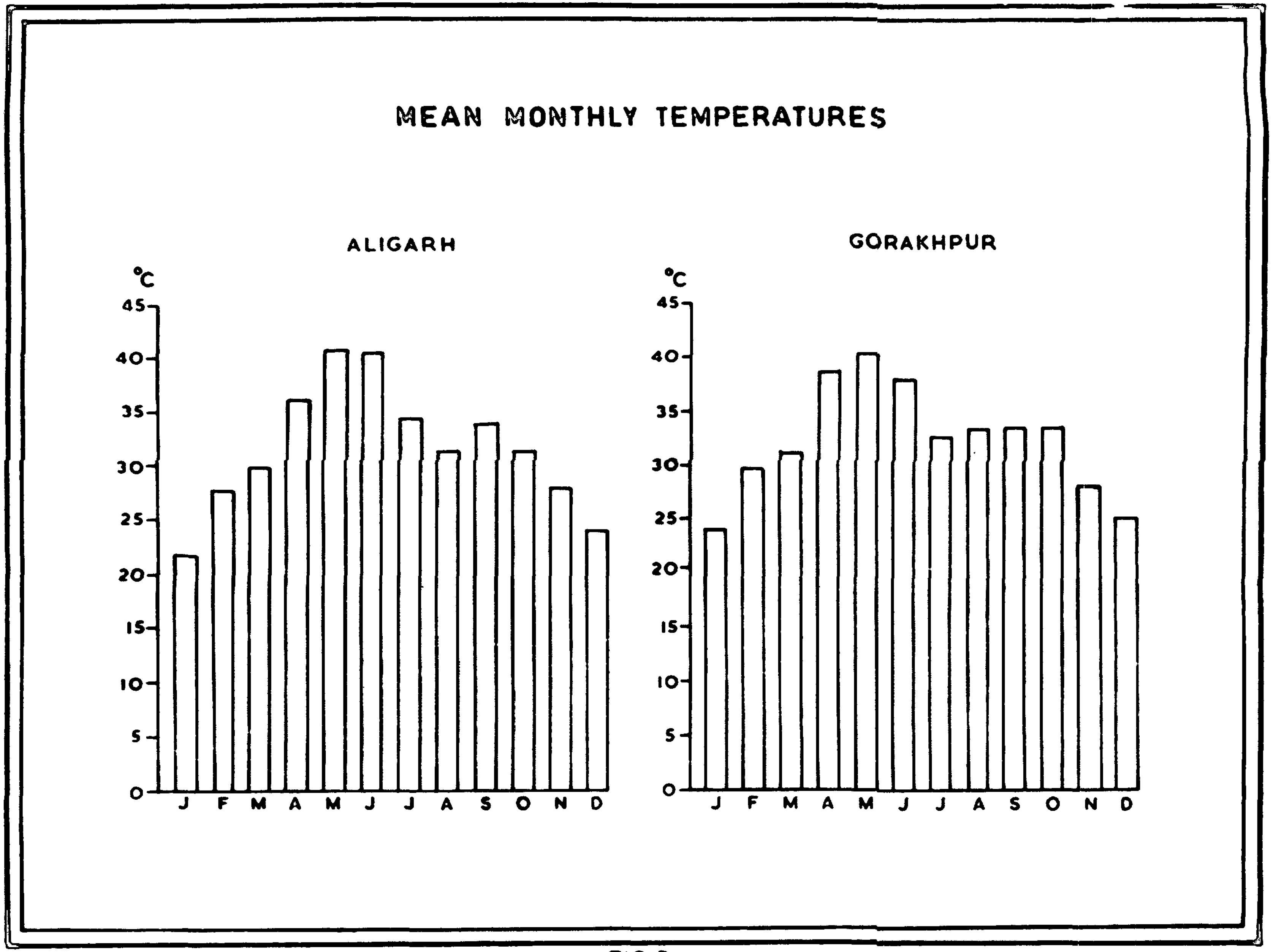
MEAN MONTHLY TEMPERATURES
ALIGARH
GORAKHPUR
°C
45
40
35
30
25
20
15
10
5
0
J F M A M J J A S O N D

FIG. 5

The month of January is the coldest of the whole year and records lowest temperature conditions. The mean minimum temperature in this month at the above mentioned stations ranges between 2.0°C and 5.4°C. While mean maximum temperature ranges between 24°C and 26°C. The occurrence of frost is quite rare, but during December and January, fog is often formed owing to temperature inversion in the three hours before or after sunrise. In February, the temperature begins to rise but the mean monthly minimum and maximum temperature still remains relatively low compared to that of November. The days are warm but the nights are cool in this month.

During this season, the velocity of the wind is least in November, but gradually increases with the advance of the season. During the months of November to February, the velocity ranges between 3 and 5 km. per hour[4] at the above mentioned stations.

A significant climatic feature of this season is the occurrence of frost which adversely affects certain crops like, arhar (pigeon pea), peas and gram are most susceptible to its adverse influence. Both, fog and frost[5] are liable to

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4. Climatological Tables of Observatories in India, op.cit., p.121.
5. The fog is locally known as '<u>kohra</u>' while frost as '<u>pala</u>', which is cooler than the <u>kohra</u>.

occur mostly in the coldest months i.e., December and January. The fog usually occurs after a winter precipitation and lasts for one or two nights.

During the season, the relative humidity[6] remains low in November being 79 per cent at Roorkee 53 per cent, at Aligarh 77 per cent, at Bareilly 70 per cent, at Allahabad 54 per cent, at Jhansi and 76 per cent in Gorakhpur and Bahraich. In January it generally increases but again decreases in February.

During the months of December, January and February a few depressions bring some rainfall. Most of these depressions are supposed to originate in the Mediterranean Sea, and few coming as distant as North Atlantic and passing over Iran move towards the east and come as far as the mid-Gangetic valley.[7] Other believe, that a fragment of the polar front is to be found in northwestern Indo-Pakistan, where northwesterly continental air invades the realm of the Indian Trades. Not frequently, these westerlies and their front extend well down the Ganga valley. Weak depressions develop along the front in northern India, providing a modest amount of winter rainfall.[8]

6. Climatological Tables of Observatories in India, (New Delhi, 1953), p.121.
7. Spate, O.H.K., Indian and Pakistan (London,1957), p.42. Kendrew, W.C., The Climates of the Continents (Oxford,1961), pp.157-59, and Trewartha, G.T., The Earth's Problem of Climates (Madison,1962),p.154.
8. Trewartha, G.T., ibid., pp.151-52.

Some believe, that the Indian monsoon is closely connected with the trade winds of the northern hemisphere and say, that the high pressure zones formed in the northern part of India play an important role in the origin of the winter monsoon in India.[9]

The precipitation from those western disturbances is usually fairly widespread and light to moderate.[10] The winter rains are important for rabi crops. But the failure or deficiency of winter rainfall affects seriously the yield of the rabi crops in northern India.

The stations in the vicinity of Himalayas receive greater precipitation than those lying far away. Fig.6 shows that some northern stations like, Dehra Dun, Naini Tal, Pauri and Almora receive greater rainfall than the central stations namely, Farrukhabad, Kanpur, Lucknow and Bara Banki. Southern stations of the State also receive less rainfall, viz., Jalaun, Jhansi, Allahabad and Mirzapur. The total rainfall varies from 180 mm. at Naini Tal to 157.2 mm. at Dehra Dun in the north to 50 mm. and 42.8 mm. at Lucknow and Sultanpur respectively in the centre, and 52.4 mm. and 54 mm. at Jhansi

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9. Voeikov, A.I., cited by Drozdov, O.A., Sorochan, O.G., and Logvinov, K.T., Study of Monsoons by Russian Scientists, Monsoons of the World, Indian Meteorological Department (New Delhi, 1960), p.121.
10. Shafi, M., Land Utilization in Eastern Uttar Pradesh (Aligarh, 1960), p.22.

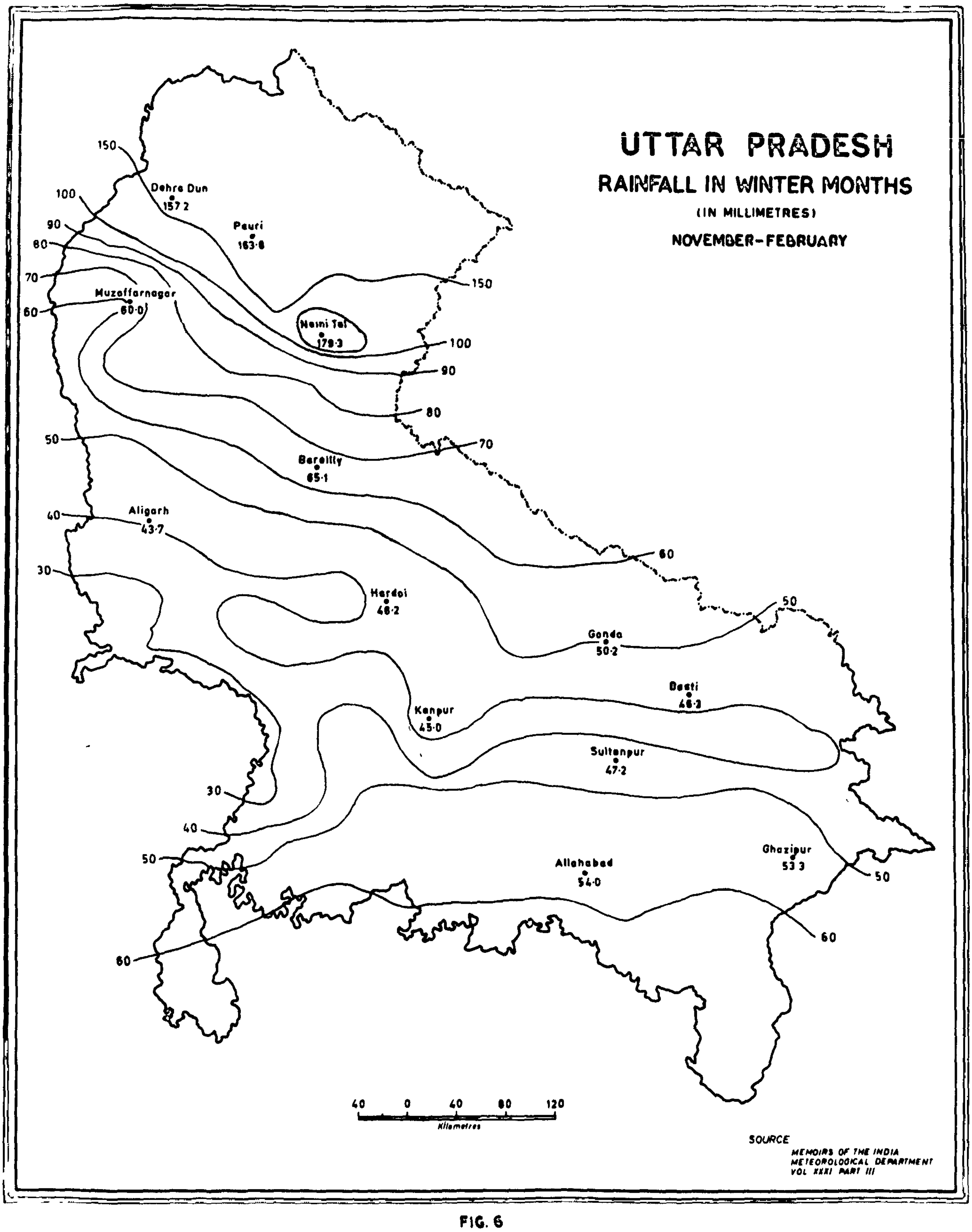
UTTAR PRADESH
RAINFALL IN WINTER MONTHS
(IN MILLIMETRES)
NOVEMBER-FEBRUARY
Dehra Dun 157.2
Pauri 163.6
Naini Tal 179.3
Muzaffarnagar 60.0
Bareilly 65.1
Aligarh 43.7
Hardoi 46.2
Gonda 50.2
Basti 46.3
Kanpur 45.0
Sultanpur 47.2
Allahabad 54.0
Ghazipur 53.3
150
100
90
80
70
60
50
40
30
40 0 40 80 120
Kilometres
SOURCE
MEMOIRS OF THE INDIA METEOROLOGICAL DEPARTMENT VOL XXXI PART III

FIG. 6

and Allahabad respectively in the south, 56.61 mm, 46.3 mm. and 38.2 mm. at Bahraich, Basti and Deoria respectively in the east and northeast. Stations situated in the west receive rainfall less than the range of 35-45 mm.

The number of rainy days ranges on an average from 1 to 1.5 in a month, and in the whole season from November to January from 2.5 to 4.5. The number of total rainy days in the season is, however, greater at the northern stations of Naini Tal and Dehra Dun than the southern stations.

The Hot Weather Season (March to mid-June)

The second half of the dry monsoon period includes the months of March, April, May and the first half of June. From the begining of March, the temperature rises abruptly and there is a continuous fall of pressure. In this month the mean monthly temperatures at Roorkee, Aligarh, Bareilly, Jhansi, Allahabad, Gorakhpur and Bahraich ranges between 21.0 C and 25.8°C. The mean minimum temperatures at these stations between 7.5°C and 12.5°C and the mean maximum between 34.5°C and 39.2°C. The days are thus warm and the nights are cool and pleasant.

A further increase in temperature takes place in the month of April. The mean minimum temperatures of the above mentioned stations ranges between 12.6°C and 19.1°C, and the mean maximum between 40.1°C and 43.2°C. The mean monthly temperature of this month ranges between 26.3°C 31.1°C.

The temperature reaches its climax in the month of May. The mean minimum temperature at the above stations varies between 18.3°C and 23.4°C, and the mean maximum ranges between 42.6°C and 45.6°C. While the mean monthly temperatures are between 30.4°C and 34.5°C (Fig.4). The excessive temperature conditions often continue and have a desiccating influence on the vegetation upto mid-June till the advent of the summer monsoon. The months before the outbreak of the monsoon namely, May and June are the hottest in Uttar Pradesh.

The relative humidity during this season remains always less than any other season. At Roorkee, it is 64 per cent in March but this percentage is reduced to 44 per cent in April and 42 per cent in May. Similarly, at other stations of the State, at Aligarh it is 50 per cent in March and is reduced to 32 per cent in April, at Allahabad it is recorded as 47 per cent in March and goes down to 35 per cent in April.

The prevalence of hot dry westerly winds, locally known as <u>loo</u> throughout the hot season which contain little moisture. The strength of these winds is subject to considerable diurnal variations. The <u>loo</u> blows during the day with a normal speed of 8 to 9 km. per hour at Aligarh, 7.5 to 8.5 km. per hour at Allahabad, 6.8 to 8.0 km. por hour at Jhansi.[11] The velocity of these winds increases from 9 a.m. till noon and whenever, the conditions favour the winds below almost with a gale force untill 2 or 3 p.m. and during the evening hours they end. Occasionally when these winds are most vigorous, the humidity to as low as 2 or 3 per cent.

The occurrence of dust storms locally known as '<u>andhi</u>' also form an important feature of this season particularly in the closing hours of hot day. The <u>andhi</u> produces a huge cloud of dust which prevail over the surface and within few minutes it obstructs the visibility in the atmosphere. These storms occur due to abnormal high temperature and least air pressure with a hot calm atmosphere. They originate generally in the afternoon or in the evening, and occasionally at night. Their velocity abnormally remain 30 to 50 km. per hour. These storms are short-lived and frequently end up in light showers of rain; sometimes they are accompanied by hail and thunder storms which modify the weather for a short period.

The rainfall during the hot weather season is associated with the storms that often form violent squalls

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11. The wind speed is based on the records climatological tables for different stations, <u>Climatological Tables of Observatories in India</u> (New Delhi, 1953).

during the heat of day. These squalls are formed owing to conventional over-turning of dry cool north-westerly wind belowing at some height above the surface of earth and hot moist wind from the sea blowing at ground level underneath the dry and cool wind.[12] These squalls are formed in the excessive heat of the day but the downward moving cool air of the upper strata causes sufficient cooling of the air before the approach of the squalls. These squalls are accompanied with condensation in the upper air but there is rarely any rain as owing to excessive heat in the lower layer, it is again evaporated before reaching the ground or is soon evaporated after its fall. The total rainfall received from the squalls during the three months March to May ranges above 100 mm. at the northern stations of the State and from 22 to 50 mm. at the remaining stations (Fig.7). Since the rainfall is associated with the occurrence of squalls, it is very much irregular in its incidence. The characteristics of rainfall of this season may be summarized as being sporadic, short-lived, subject to great local variations, and frequently repeated day after day for many days in succession about the same hours.[13]

The high temperature, low humidity and cloudless skies of March and April favour the ripening of <u>rabi</u> crops

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12. Kendrew, W.G., <u>The Climates of the Continents</u>, op. cit., p.106.
13. Blanford, H.F., The Rainfall of India, <u>Memoirs of the Indian Meteorological Department</u>, Vol.III, 1886-88, p.95.

UTTAR PRADESH
RAINFALL IN SUMMER MONTHS
(IN MILLIMETRES)
MARCH-MAY
Dehra Dun
93.3
Pauri
137.7
Muzaffarnagar
36.9
Naini Tal
174.7
Bareilly
36.1
Aligarh
35.0
Farrukhabad
28.4
Agra
24.1
Gonda
49.7
Gorakhpur
60.9
Kanpur
22.9
Hamirpur
22.3
Allahabad
22.4
Ghazipur
27.2
100
60
50
40
30
20
Kilometres
SOURCE
MEMOIRS OF THE INDIA METEOROLOGICAL DEPARTMENT VOL XXXI PART III

FIG. 7

and are helpful in the process of winnowing. The increased wind speed in April and early May helps much in winnowing the cereal grains. After harvesting, the fields remain barren and ceases, till the advent of the monsoon rainfall, as the vegetative growth in the latter half of the season is hindered due to dessicating effect of excessive dry weather conditions.

The Season of Rains (Mid-June to October)

In June the features of hot weather season become more intensified and the continuous heat and dryness of the air causes unbearable conditions. With the 'burst' of monsoon, it brings a complete change in the weather. Its major effect is a great fall in the temperature, the mean minimum temperature at Roorkee, Aligarh, Bareilly, Jhansi, Allahabad, Gorakhpur and Bahraich ranges between 20.9°C and 24.0°C, and the mean maximum temperature varies between 41.4°C and 44.2°C. The mean monthly temperature of this month ranges from 32.2°C to 34.5°C.

Each of the mean minimum, mean maximum and mean monthly temperatures (Figs.4 & 5) has gradually a continuous fall from June to the end of August at all stations. The mean maximum temperature in September shows a little increase from August, but the mean minimum temperature records a decrease.

During this season, the hailstorms, fog or frost are commonly absent. The relative humidity increases from June to August. A comparison of relative humidity at different stations shows, that in each of the months from July to October it remains generally high. In the northwest at Roorkee it is about 80 per cent, at Gorakhpur in the northeast about 85 per cent and at Allahabad in the south about 82 per cent. It is highest at all stations in the months of July and August - the period of growth of the <u>kharif</u> crops.

The jet monsoon stream, characterised by heavy and prolonged rainfall is a large scale inflow of moist maritime ~~air. It gives~~ widespread rains over most of the area (Fig.8). The setting of monsoon rainfall is not equal in all parts of the State. The time of its occurrence at various places may also vary. The average rainfall during the monsoon months varies from west to east the areas being below 700 mm. are in the west (695 mm. at Meerut, 577 mm. at Bulandshahr, 693 mm. at Aligarh and 488 mm. and 619 mm. at Mathura and Agra respectively), and more than 1000 mm. in the east (at Basti 1200 mm, Gorakhpur 1260 mm, Deoria 1050 mm, Ghazipur and Ballia 1070, and 1100 mm. respectively).

A comparison of Fig.9 shows that 80 to 90 per cent of the annual rainfall is received during the five months -

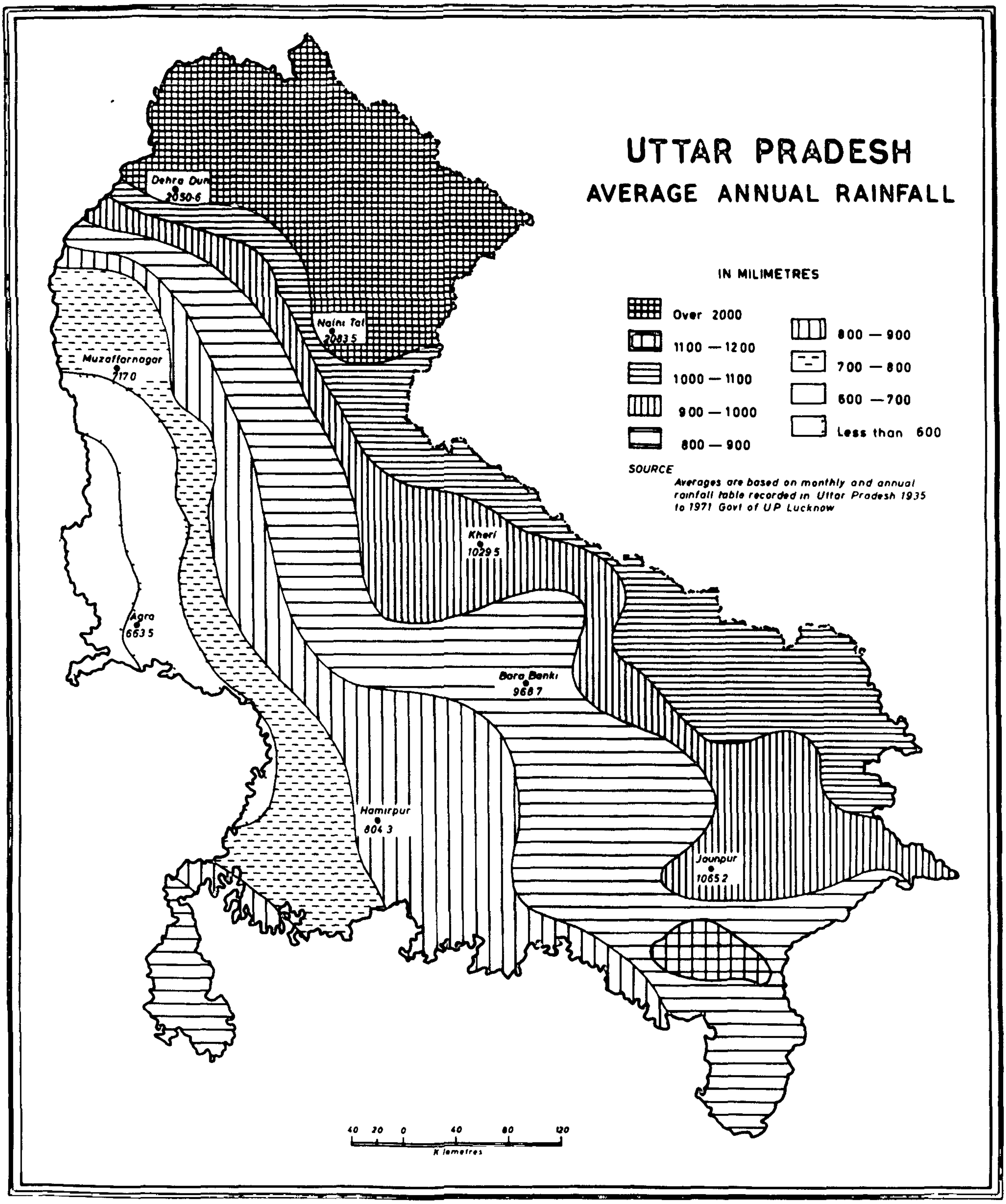
UTTAR PRADESH
AVERAGE ANNUAL RAINFALL
IN MILIMETRES
Over 2000
1100 — 1200
1000 — 1100
900 — 1000
800 — 900
800 — 900
700 — 800
600 — 700
Less than 600
SOURCE
Averages are based on monthly and annual rainfall table recorded in Uttar Pradesh 1935 to 1971 Govt of U P Lucknow
Dehra Dun
2050·6
Naini Tal
2083 5
Muzaffarnagar
717 0
Kheri
1029 5
Agra
663 5
Bara Banki
968 7
Hamirpur
804 3
Jaunpur
1065 2
40 20 0 40 80 120
Kilometres

FIG 8

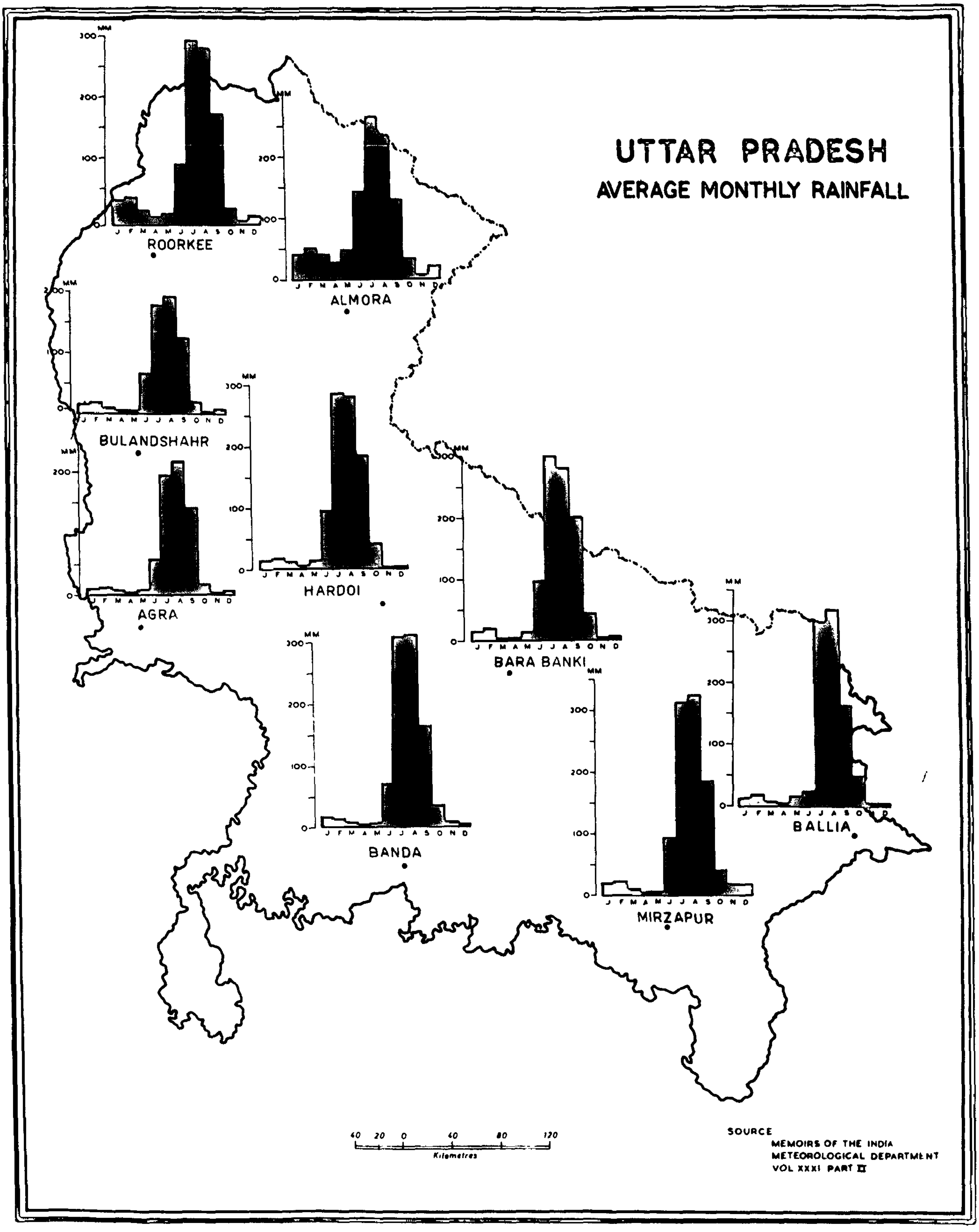
UTTAR PRADESH
AVERAGE MONTHLY RAINFALL
ROORKEE
ALMORA
BULANDSHAHR
AGRA
HARDOI
BARA BANKI
BANDA
MIRZAPUR
BALLIA
Kilometres
SOURCE
MEMOIRS OF THE INDIA
METEOROLOGICAL DEPARTMENT
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FIG. 9

June to October, 5 to 10 per cent is received from November to February and 2.5 to 5 per cent is received in March to May. Rainfall distribution has the same pattern in the wet monsoon as that of the annual rainfall and decreases from east to west as well as from north to south. The period of wet monsoon does not constitutes a continuation in rainy days, but the outbursts of rain are alternated with the spells of fine and pleasant weather, which are very much advantageous to the crops of that season. These spells of fine weather are produced by 'a shoulder of high pressure' and short-lived covering the whole of Uttar Pradesh by pushing the axis of the low pressure trough of North India towards the foothills of Himalayas. Due to such conditions the easterly winds fail to cross the Ganga Valley and this causes a break in the monsoon.[14] Therefore, the stations located in the upper Ganga valley receive less rainfall.

VARIABILITY OF RAINFALL

Annual Variability

The annual variability,[15] of rainfall in Uttar Pradesh ranges from 8 per cent at Allahabad to about 20 per cent

14. Blanford, H.F., op. cit., p.217.
15. The variability of annual as well as in the wet monsoon rainfall has been calculated by the writer on the method evolved by P.R. Crowe. The rainfall

contd.....

at Mathura (Fig.10). A comparison of average annual rainfall and the mean annual variability (Figs. 8 & 10) shows, that in the northwestern and western parts of the State where the distribution of rainfall is less, has proportionately higher

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data for 37 years (1935-71) obtained from the records of Monthly and Annual Rainfall in Uttar Pradesh were arranged in ascending order for seperate stations. Upper quartile, median and lower quartile were marked in the series and the variability of rainfall in interquartile range as percentage to the median was computed. The method would be read as follows:

$$\frac{\text{Upper Quartile} - \text{Lower Quartile}}{\text{Median X 2}} \text{ X } 100$$

Normal rainfall obtained for a number months or year by arithmetic mean is quite erroneous owing to its obvious shortcoming of being sensitive to occasional heavy rainfall. The variability computed from these normals is also liable to serious errors. The method evolved by Crowe is based on quantitative foundations, and the values derived by this method are more expressive of the sequence of rainfall and its variation in each months.

For a detailed knowledge of the method evolved by Crowe, and its application to rainfall studies of different regions see:

Crowe, P.R., "The Analysis of Rainfall Probability - A Geographical Method and its Application to European Data", Scottish Geographical Magazine, Vol.XLIX, 1933, pp.73-91.

Ramamurthy, K., "The Rainfall Regime of Vellore", Indian Geographical Journal, Vol.XXVI, No.3, 1936, pp.463-84.

Mathews, H.A., "A New View of Some Familiar Indian Rainfall", The Scottish Geographical Magazine, Vol.LII, No.2, 1936, pp.84-97.

Savur, S.R., The Median as Static, Current Science, Vol.V, 1937, pp.564-76.

Ramamurthy, K., Some Aspects of the Regional Geography of Tamilnad Climate, Indian Geographical Journal, Vol.XXIII, No.3, 1948, pp.20-64.

Mahalingam, L.S., "An Analysis of Indian Rainfall Using the Median as a Static", Indian Meteorological Department Scientific Notes, Vol.VII, No.82,pp.243-54.

Monkhouse, F.J. and Wilkinson, H.R., Maps and Diagrams (London, 1967), pp.193-95.

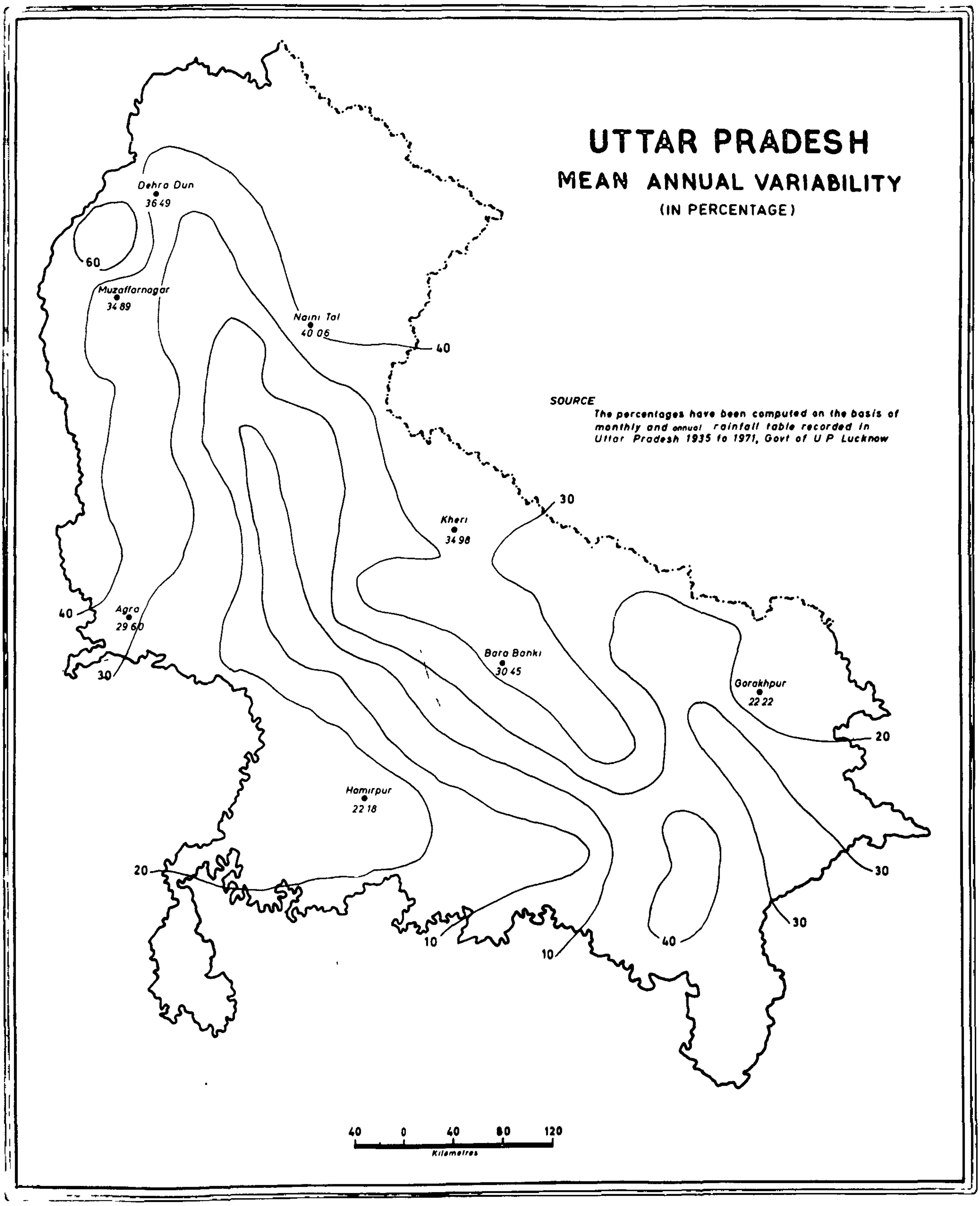

UTTAR PRADESH
MEAN ANNUAL VARIABILITY
(IN PERCENTAGE)
SOURCE
The percentages have been computed on the basis of monthly and annual rainfall table recorded in Uttar Pradesh 1935 to 1971, Govt of U P Lucknow
Dehra Dun
36 49
60
Muzaffarnagar
34 89
Naini Tal
40 06
40
Kheri
34 98
30
Agra
29 60
40
30
Bara Banki
30 45
Gorakhpur
22 22
20
Hamirpur
22 18
20
10
10
40
30
30
40 0 40 80 120
Kilometres

FIG. 10

tendency of deviation from the mean than the southern and northeastern parts where rainfall is relatively high. The area of the largest percentage of mean annual variability corresponds to the area of the least rainfall in the summer monsoon months i.e., mid-June to October as well as to that of least annual rainfall (Fig.10). Here the variability of rainfall both at Roorkee and Mathura is 20 per cent and Meerut 19 per cent. The other area of high variability extends in the eastern part of the State, the variability being 19.2 per cent at Jaunpur, 14.2 per cent at Sultanpur, and 13.5 per cent at Ghazipur. Besides these, there are certain pockets where variability is high, such as Hardoi in the centre where it is 14.2 per cent and in the Naini Tal a mountainous area where it is 17.5 per cent.

It is assumed, that any place with a rainfall variability of 12 per cent or is liable to the occurrence of famine[16] and in this respect most of the areas of Uttar Pradesh with the exception of a small pockets in the south and northeast are susceptible to famine. The total rainfall at different stations has generally large variations from the average from place to place as well as from year to year, which is particularly a common feature due to fluctuating

16. Blanford, H.F., Rainfall of India, op. cit., p.130. See also, Williamson, A.V., Irrigation in the Indo-Gangetic Plain, Geographical Journal, Vol.65, No.2, 1925, p.143.

nature of rainfall makes agriculture in certain regions of Uttar Pradesh precarious and artificial arrangements for irrigation have been made to irrigate the cultivated land in those areas. For instance, the annual rainfall at Roorkee in 1935 was 500.2 mm. which is for below the average, while in the same year, it was above the average at Muzaffarnagar, Jhansi and Gorakhpur being 707.7, 1021.4 and 1230.7 mm. respectively. Similarly, in 1940 the rainfall was 1115.4 mm at Bareilly, being above the average, when it was 537.5 and 819.0 mm at Muzaffarnagar and Jhansi respectively, which is below the average. It was below the average in 1960 at Bareilly and Gorakhpur stations. The year 1971 shows a variation above the average at Muzaffarnagar, Sultanpur, Mirzapur, and Gorakhpur (Figs. 11, 15, 16 & 17).

The variability in the distribution of rainfall also exists from one year to another at a certain place. If the rainfall in one year is on the average, it is liable next year to be below or above the average. The annual rainfall for example, at Roorkee was below the average in 1964, whereas, in its preceding year it was recorded far above the average (Fig.14). The rainfall at Muzaffarnagar received in 1942 was more than the double what it was recorded in the preceding year (Fig.11). This type of climatic phenomena can be observed at any station. The monsoon activities and the distribution of rainfall are liable to considerable variations.

ANNUAL RAINFALL

1935-71

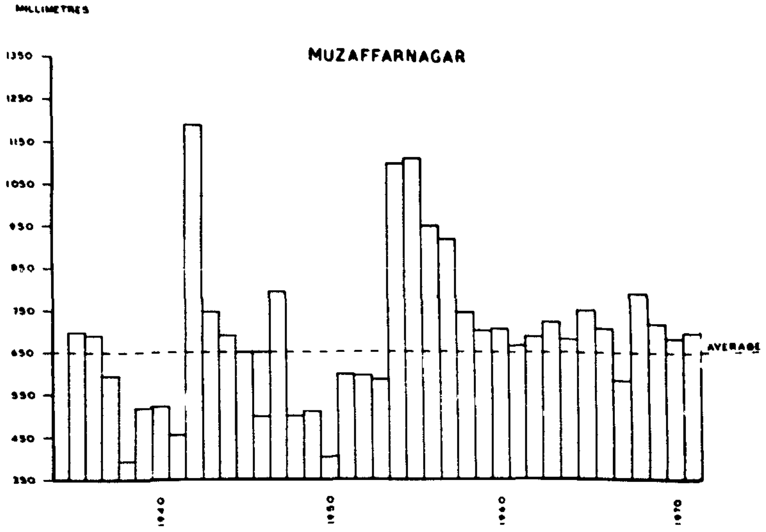


FIG. 11

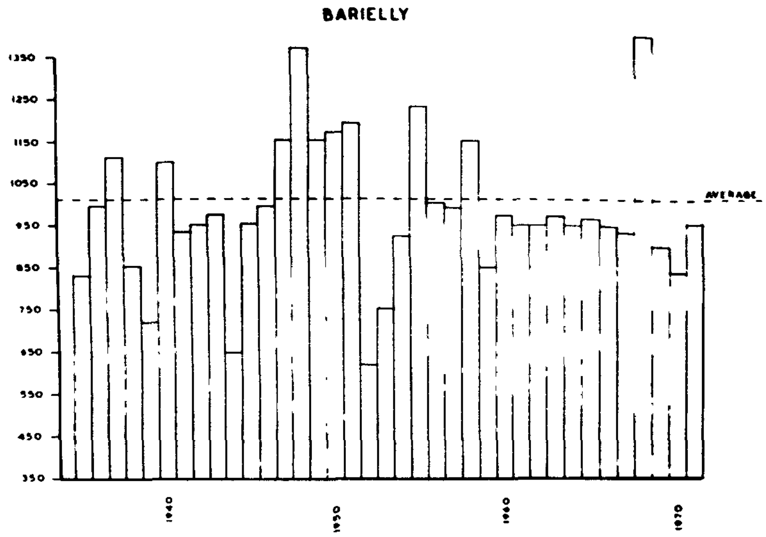


FIG. 12

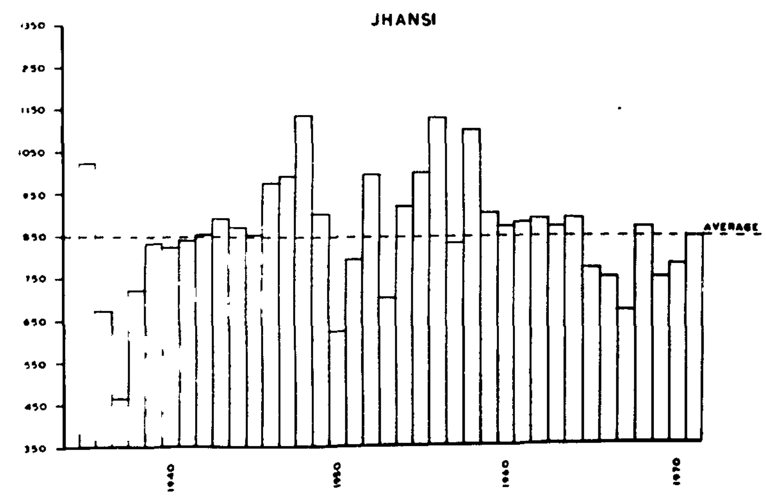


FIG. 13

ANNUAL RAINFALL

1935-71

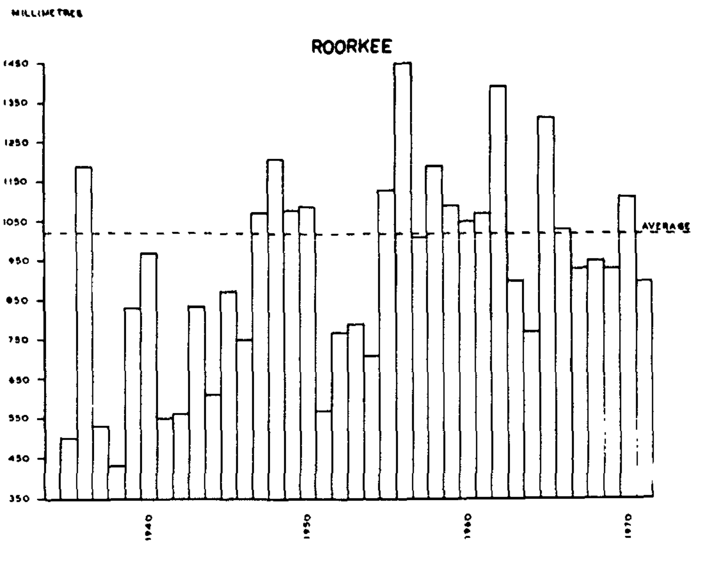


FIG. 14

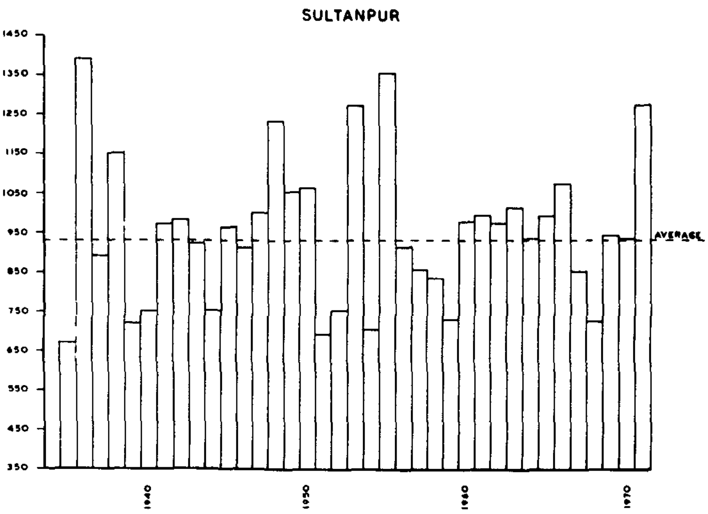


FIG. 15

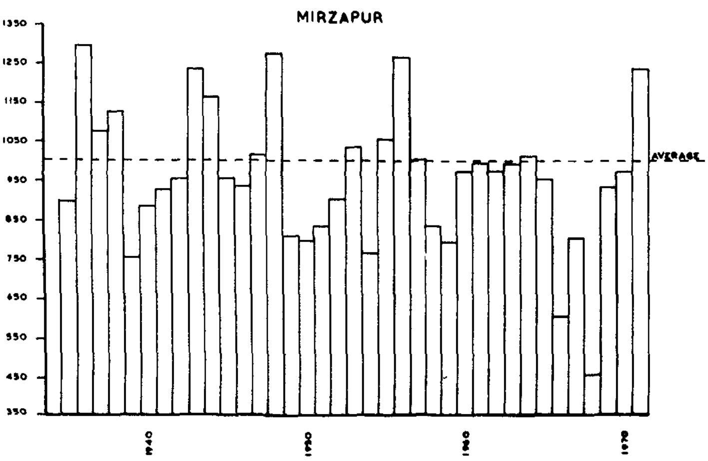


FIG. 16

ANNUAL RAINFALL
1935-71

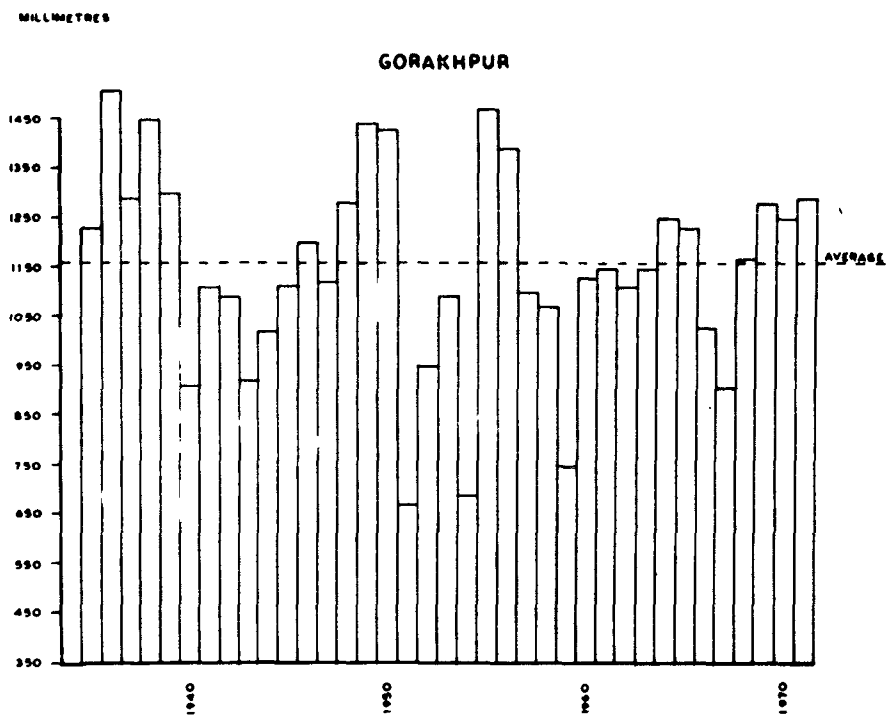


FIG. 17

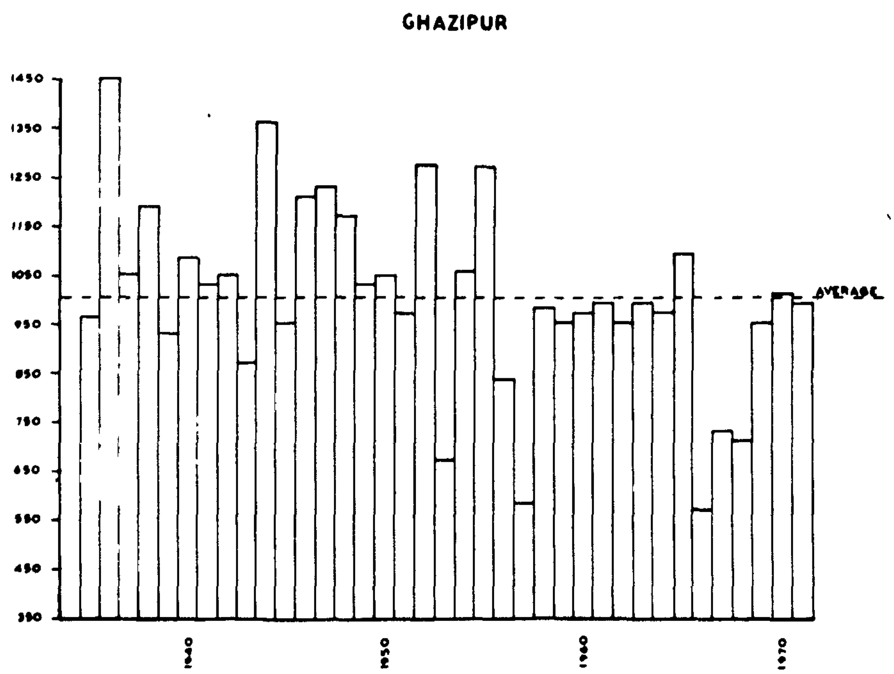


FIG. 10

SOURCE:
FIGURES 11 TO 18
ARE BASED ON ANNUAL
RAINFALL STATISTICS
GOVT. OF UTTAR PRADESH

It can be seen from the Figs.12 to 19, that the rainfall in a given year is more than enough at a place causing conditions of floods while at another place it may be lesser than the average or equal to the average in the same year. For instance, during 1940 the rainfall was below the average at all stations excluding Sultanpur and Ghazipur, where it was recorded more than the average (Figs.15 & 18).

Variability in the Wet Monsoon Months

About 90 per cent of the total rainfall in Uttar Pradesh is received during the wet monsoon months. From agricultural point of view, the distribution and variation of rainfall in these month's is quite significant owing to its effect on the crops of both <u>kharif</u> and <u>rabi</u> seasons. Whenever, the rainfall is excessive during the month of June the sowing date of early <u>kharif</u> crops is delayed leading to low yield of the crops. September is the most critical month for the farmers as any excess or deficiency of rainfall in this month has large-scale repurcussion on the crops of <u>kharif</u> and <u>rabi</u> season. Rainfall in this month is necessary to mature <u>kharif</u> crops and to soften the ground for <u>rabi</u> ploughing. But, heavy falls lead to water-logged conditions, while premature condition of the rains may cause postponment of restriction of <u>rabi</u> sowing.[17] On the other hand, if the

17. Clark, K.G.T., "The Vicissitudes of the Summer Rainfall of the Indo-Gangetic Plain and the Assam Valley", <u>Geography</u>, Vol.XVII, Part IV, 1932, p.288.

monsoon rain comes in light but in regular showers and lasts till the end of September, the outturn of kharif crops is good, and apparently there is a large extension of the area under plough for sowing rabi crops. In this way, the agricultural operations are largely controlled by the rainfall of this month. The timely distribution of rainfall is rather more important than the total rainfall of the year. The extent of variability to which these months are liable is given in the Table I. The range of monthly variability is shown in the rainfall dispersion diagrams (Figs.19 to 28).

It will be seen from Table I, that the variability in the month of June is sufficiently high at Bulandshahr and Jhansi being 40.90 and 40.76 per cent respectively and varies between 46 to 50 per cent at Aligarh and Ballia. Among other places, it is 35 per cent at Roorkee, 37.5 per cent at Jaunpur, 45 per cent at Mathura and 41 per cent at Allahabad. The months of July and August have the least variability, below 35 per cent throughout the State. And at certain stations, it is as low as 5.5 per cent at Jalaun and 10 per cent at Kheri. The value of variability in the month of September ranges from 52 and 62 per cent respectively at Ballia and Meerut. In this month too, we notice a high variability. In the month of October, the variability figures further go upto a maximum level as 80.5 per at Bulandshahr and 60.5 per cent at Etah.

RAINFALL DISPERSION DIAGRAMS

JUNE-OCTOBER

1935-71

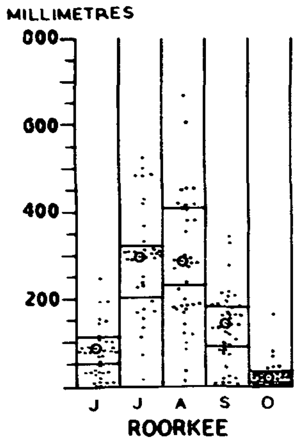


FIG. 19

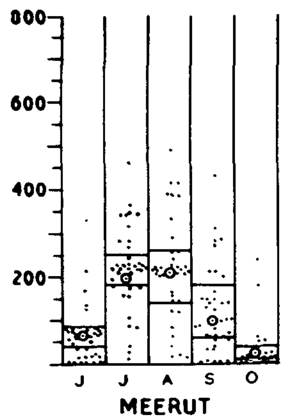


FIG. 20

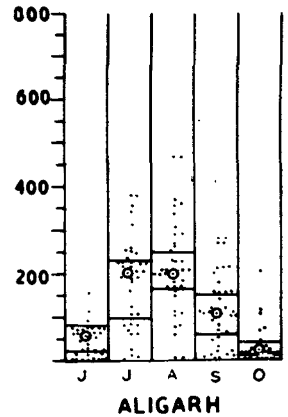


FIG. 21

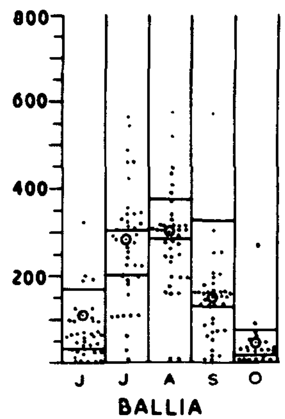


FIG. 22

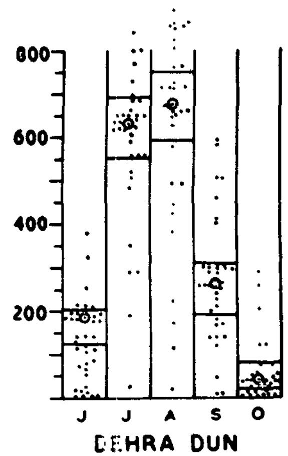
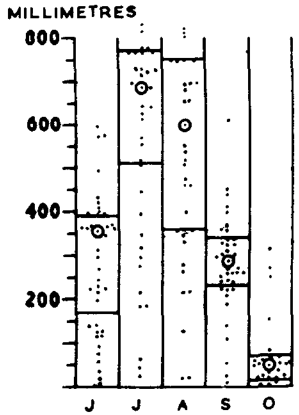


FIG. 23

RAINFALL DISPERSION DIAGRAMS

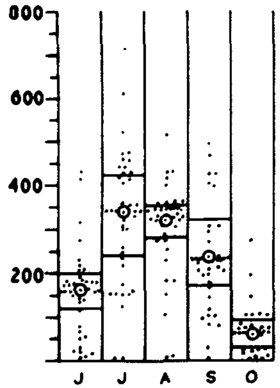
JUNE-OCTOBER

1935-71



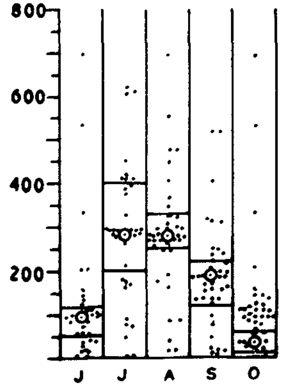
NAINI TAL

FIG. 24



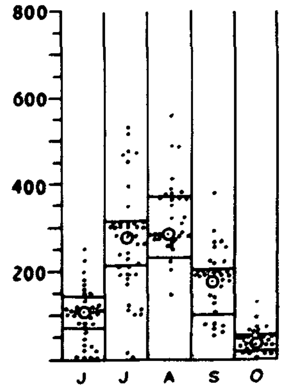
GORAKHPUR

FIG. 25



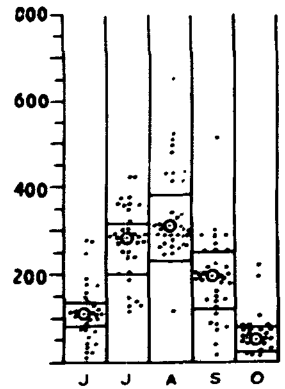
HARDOI

FIG. 26



SULTANPUR

FIG. 27



GHAZIPUR

FIG. 28

FIGURES 19 TO 23 ARE BASED ON MONTHLY RAINFALL STATISTICS PUBLISHED BY GOVT. OF U.P. FOR THE YEARS 1935-71

TABLE I

Mean monthly and annual variability at selected stations in Uttar Pradesh

Stations	MONTHS					
	June % ±	July % ±	August % ±	September % ±	October % ±	Annual % ±
1	2	3	4	5	6	7
Dehra Dun	21.19	11.12	24.82	22.62	63.41	26.49
Roorkee	35.79	18.81	30.66	32.62	66.66	65.51
Muzaffarnagar	24.69	24.48	26.88	67.00	78.12	24.89
Meerut	26.92	15.99	28.16	61.76	52.50	42.09
Bulandshahr	40.90	22.62	46.61	43.30	80.55	32.82
Aligarh	46.26	32.53	20.39	42.85	61.11	34.92
Mathura	45.83	31.32	18.45	27.10	42.30	44.22
Agra	29.41	12.50	21.86	41.74	42.10	29.64
Bareilly	14.03	6.72	18.85	28.23	37.50	23.97
Moradabad	23.24	11.57	20.43	23.60	58.69	13.13
Pilibhit	26.60	12.62	21.83	29.90	41.17	24.50
Etawah	26.22	25.75	18.42	32.33	60.52	19.77
Allahabad	41.00	10.41	16.55	28.21	52.50	12.21
Jhansi	40.76	10.19	18.05	20.07	81.25	19.11
Jalaun	16.43	5.42	16.34	31.67	47.05	20.45
Banda	34.17	22.45	10.16	22.18	44.44	22.18
Mirzapur	24.19	21.17	14.93	33.83	42.50	26.35
Jaunpur	37.50	15.13	23.45	25.58	58.88	41.50
Ghazipur	25.00	12.19	17.10	26.75	33.92	41.96
Ballia	49.62	17.53	14.37	51.75	68.36	30.80

TABLE I (Contd.....)

1	2	3	4	5	6	7
Gorakhpur	17.24	27.50	11.49	33.11	55.83	26.83
Beoria	17.78	19.14	16.02	32.51	49.12	22.22
Basti	11.45	16.46	16.99	24.59	45.76	16.65
Hamirpur	40.83	14.70	18.70	18.92	42.85	26.11
Naini Tal	32.02	18.57	29.89	20.43	38.79	40.06
Hardoi	32.65	34.32	14.07	23.65	43.75	36.65
Kheri	29.65	9.25	14.70	12.95	68.42	34.98
Gonda	28.57	24.71	19.09	17.44	46.87	20.00
Bahraich	23.37	26.61	24.32	24.38	45.00	23.91
Sultanpur	31.35	17.07	15.76	26.78	47.61	29.13
Bara Banki	23.07	23.97	17.79	15.86	36.48	30.45

Variability from the Median

The variability of rainfall from month to month i.e., June to October is shown on Figs.19 to 28 drawn after the method of Crowe for a monthly data of 37 continuous years. He points out, that the ordinary average rainfall at a certain place is sometimes insufficiently sensitive and at other times over-sensitive leading to extreme variations.[18] In order to analyse the variability of rainfall from June to October by the Crowe's method the distribution of monthly rainfall covering a period of 37 years (1935-71) for ten selected stations has been shown on Figs.19 to 28. It should

18. Crowe, P.R., op. cit., p.73.

be pointed out at first, that among the selected stations Roorke, Meerut and Aligarh (Figs.19 to 21) represent the northwestern part of the State, Ballia and Ghazipur are selected to represent the extreme eastern part, Dehra Dun and Naini Tal are representatives of sub-Montane tract, the Gorakhpur station represent the Trans-Ghaghara plain i.e., northeastern part, and the remaining two stations Hardoi and Sultanpur are selected to represent the central part of the State.

The rainfall dispersion diagrams of the three northwestern stations (Figs.19 to 21) show a considerable similarities. Here both the months July and August enjoy the highest rainfall and similar patterns in dispersion of rainfall and do not possess any difference which may be encounted as an important aspect for agriculture. Both Ballia and Ghazipur eastern most stations follow the same pattern of dispersion as that of northwestern stations. The picture at two northern stations is rather critical. The four months here starting from June to September show a pronounced variability (Figs.23 & 24). Therefore, the sowing periods are liable to be affected very seriously. The variability at Gorakhpur is quite significant for the three months July to September as compared to other stations (Fig.25). The dispersion pattern at both the central stations, viz., Hardoi and Sultanpur is to some extent identical, in the sense, that both of them show no significant difference (Figs.26 & 27). Rainfall dispersion in the months of July and August at both of them is largely variable. And at Hardoi station too, shows little variability in the months of June and October.

During the month of October the inter-quartile range at the three northwestern stations (Figs.19 to 21) is very small and there were six years in which this month received not a single drop of rain, and about four years in which rainfall was insignificant. The rainfall received in the month of September shows a higher range of variability at eight out of ten stations except, Dehra Dun and Naini Tal, where it is significant also in the month of June. Consequently, the agricultural operations depend out on variability of those months.

It may thus be seen at all stations more or less during three months i.e., July to September dispersions of rainfall are fairly significant as indicated by inter-quartile ranges. But this variability during these months is of less significance in view of heavy amounts of rainfall received. But, for the month of June, much smaller variability may hinder the agricultural operations because monthly median remains low and further any reduction in this amount can compel the farmers to postpone the agricultural operations.

Thus, the variability study of rainfall in the State of Uttar Pradesh leads one to conclude, that two months of October and June are most critical from the point of view of variability, and this may be followed by the month of September. It is also significant to note, that rainfall in both the months is liable to be deficient.

CHAPTER III

SOILS

Adequate scientific records are not available covering detailed informations about the soils of Uttar Pradesh. The oldest sources of information are, the Settlement Reports, District Gazetteers, Assessment Reports, and the Revenue Records which provide a texural classification of soils. The soil surveys of some scattered areas have been carried in recent years, which provide a generalised information and do not show accurately the soil sub-divisions of the area. A wide range of soils, both of residual and alluvial origin are found, and the major area is occupied by the alluvial soil (Fig.29).

The residual soils occupy the Hilly, Bundelkhand and Vindhayan regions comprising the northern and the southern parts of the State. The alluvial soils are spread of the central part covering the whole of the region commanded by Ganga and Yamuna rivers, flanked in the west and east by well defined productive soils.

Based on geological and pedogenic characteristics, differing from one another seven well defined groups of soils have been recognised in the State.[1] The detailed or even

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1. Melhotra, C.L., "Soils of Uttar Pradesh their Broad Distribution and Management", Fertilizer News, Vol.XVII, No.6, 1972, p.79.

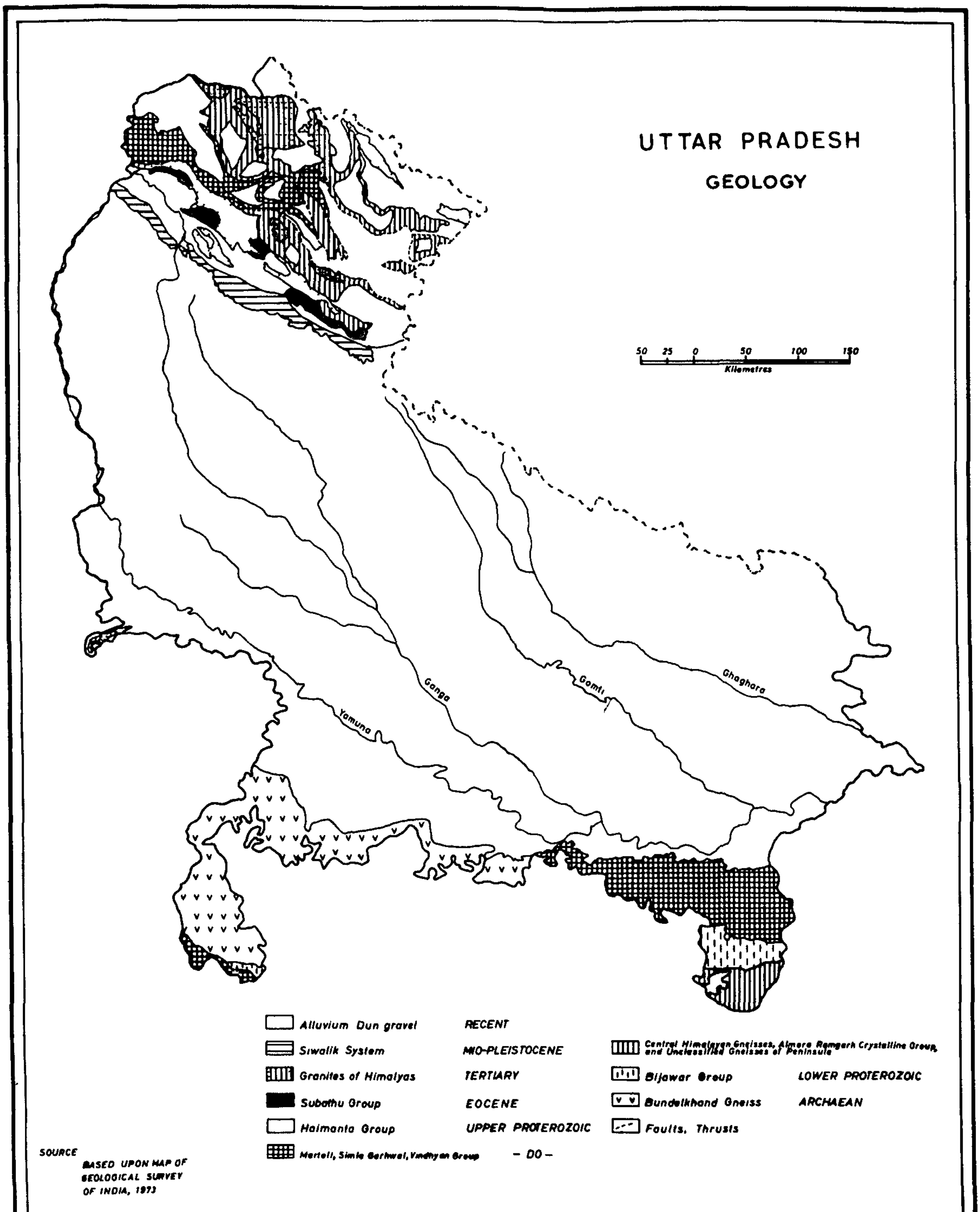
UTTAR PRADESH
GEOLOGY
50 25 0 50 100 150
Kilometres
Ganga
Yamuna
Gomti
Ghaghara
Alluvium Dun gravel
RECENT
Siwalik System
MIO-PLEISTOCENE
Granites of Himalyas
TERTIARY
Subathu Group
EOCENE
Haimanta Group
UPPER PROTEROZOIC
Martoli, Simla Garhwal, Vindhyan Group
- DO -
Central Himalayan Gneisses, Almora Ramgarh Crystalline Group, and Unclassified Gneisses of Peninsula
Bijawar Group
LOWER PROTEROZOIC
Bundelkhand Gneiss
ARCHAEAN
Faults, Thrusts
SOURCE
BASED UPON MAP OF
GEOLOGICAL SURVEY
OF INDIA, 1973

FIG. 29

reconnaissance soil map of the State has so far not been completed. A tentative map showing the distribution of soil groups prepared by the State Survey Organization is available (Fig.30). The area occupied and the distribution pattern of each group of soil is given in Table II.

TABLE II

Broad soil groups of Uttar Pradesh and their distribution

Soil groups	Area in hectare	Percentage
Hill soils	4,217,440	14.33
Bhabar soils	590,510	2.00
Tarai soils	1,686,740	5.73
Alluvial soils	18,185,300	61.78
Vindhayan soils	1,501,290	5.10
Bundelkhand soils	3,192,440	10.85
Aravali soils	63,290	0.21

Source: Melhotra, C.L., Soils of Uttar Pradesh their Broad Distribution and Management, op. cit., p.79.

Hill Soils

This group of soils is found in the northern portion of the State and accounts for 14.33 per cent of the area of the State, comprising the hills of Kumaon and Garhwal

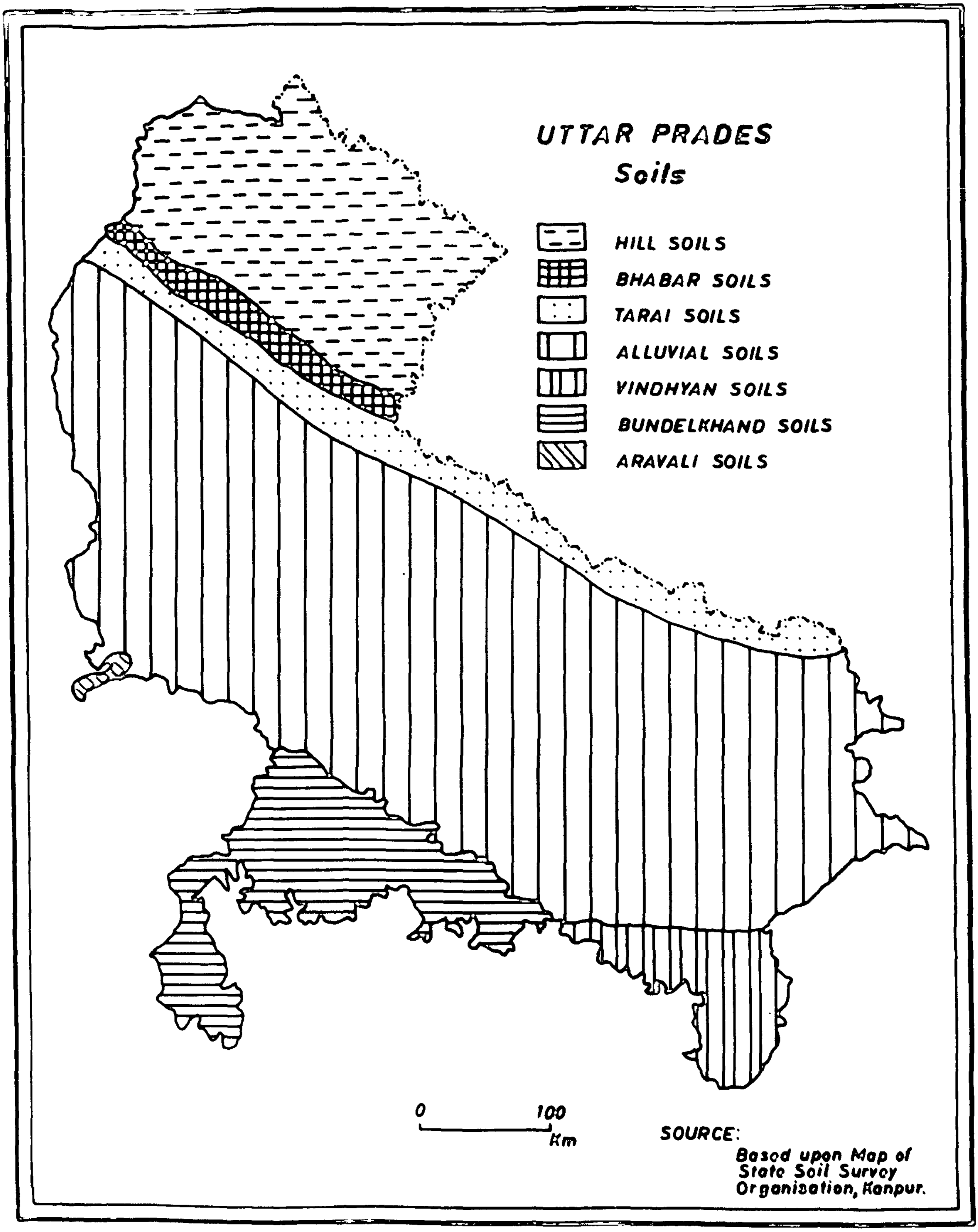
UTTAR PRADES
Soils
HILL SOILS
BHABAR SOILS
TARAI SOILS
ALLUVIAL SOILS
VINDHYAN SOILS
BUNDELKHAND SOILS
ARAVALI SOILS
0
100
Km
SOURCE:
Based upon Map of
State Soil Survey
Organisation, Kanpur.

FIG. 30

and part of the southern outer spurs of Himalays belonging to extra peninsular region of immense thickness and represents all systems from Tertiary or Quaternary sediments of fluviatile nature. The spa-n of hill soils is extended into the eight hilly districts, viz., Almora, Chamoli, Garhwal (Pauri and Tehri), Naini Tal, Pithoragarh, Uttar Kashi and Dehra Dun. The parent rock materials are mostly biotite-schists and granite-gneiss. Regarding the fertility status the districts of Uttar Kashi, Chamoli and Pauri Garhwal have a fair preponderance of acidic soils, while those of Tehri Garhwal, Almora and Dehra Dun have small patches of acidic soils. The soils of Pithoragarh and Naini Tal passes very little acidic character. In this group of soils normal reaction predominate between the range of 59 to 66 per cent in the former three districts, and 81, 89 and 92 per cent the latter districts respectively.[2] Practically, no alkaline soils are reported in this group, except for the district of Pithoragarh. The availability of phosphorus falls in medium category in the districts of Chamoli, Pauri Garhwal, Almora and Pithoragarh, the remaining districts show low phosphorus distribution. Potash distribution has been found to be high in Tehri Garhwal, Dehra Dun and Uttar Kashi, but

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2. Melhotra, C.L. and Singh, T., "Fertility Status of Uttar Pradesh Soils", <u>Fertilizer News</u>, Vol.XIV, No.9, 1969, p.34.

medium in the districts of Almora, Pithoragarh and Pauri Garhwal. The concentration of potash is low only in the districts of Chamoli and Naini Tal. Organic carbon is high in the soils of Uttar Kashi, Tehri Garhwal, Pithoragarh and Dehra Dun districts. The values of organic carbon are moderate in the soil of Chamoli, Pauri Garhwal, Almora and Naini Tal districts. The problem of high soluble salt contents is not found in this region.

The natural vegetations of the area are the forests of Oak and Pine, with luxuriant undergrowth of grasses, weeds and herbs.

Bhabar Soils

This group of soils occur only in the form of a narrow strip (Fig.30) in the foothill region of the outer spurs of Himalayas throughout its east-west expanse in the districts of Dehra Dun, Saharanpur, Bijnor, Garhwal and Naini Tal. These soils have developed under a sub-humid and moist climate which becomes dry during summer months. These soils have been formed by the mechanically transported alluvium from the adjoining Siwalik and Himalayan ranges comprising sand stones in rapid state of weathering and conglomerates interstratified with boulders alongwith purple shales and clays.

The soils of the area are underlain by large or small sized pebbles and coarse gravel detritus, mechanically transported from adjoining hills. The soils are of dark grey to black colour and are moderately alkaline in reaction. They are rich in plant nutrients, but inspite of this they fail to support norma-l cultivation, specially due to the acute scarcity of moisture resulting from the disappearance of streams coming from the adjacent Siwalik owing to rapid percolation. This excessive percolation results presence of the bolders made of sub-stratum below the surface which drains out all the water under ground and which ultimately emerges again in the adjoining Tarai tract.

These soils support only inferior crops of shorter maturity which require less water. Shifting cultivation is the usual practice in this area.

Tarai Soils

This group of soils occur immediately adjacent to the strip of Bhabar soils in the form of a narrow belt below the Himalayas extending from Dehra Dun in the northwest to the extreme northeastern district of Deoria in the State. The expanse of this type of soil is 5.73 per cent of the total area of the State (Table II). The Tarai tract can be divided into two distinctly different systems: (i) northwestern Tarai extending from Dehra Dun to Kheri, and (ii) northeastern Tarai extending from Bahraich to Deoria district, upto its border with the State of Bihar. The climate in Tarai area is generally damp and unhealthy, and is categorised as sub-humid with annual precipitation ranging from 1000 to 1500 mm, maximum rainfall coming in the months of July to September. These soils remain saturated during the monsoon months and bear fairly moist nature during the succeeding winter due to the very high level of underground water. It is on this account, that these soils have received the nomenclature of Tarai, meaning the moist humid area. Ground water aquifers are very common in northwestern Tarai and artisan wells are frequently met within the region.

In Tarai tract, the soils have generally a normal reaction and normal salt content, except for the Tarai areas of Gorakhpur, which comprises the well known '<u>bhat</u>' soil. These soils are deficient in available phosphorus in the districts of Saharanpur, Kheri and Gonda. In the remaining districts of this tract, viz., Bijnor, Bahraich, Basti, Gorakhpur and Deoria these soils have medium phosphorus status. Available potash content in the Saharanpur soils is high, but the soils in Bijnor, Gonda, Basti and Deoria districts are low to medium in available potash content.

Organic carbon status in this tract is generally medium except for Deoria and to some extent in Gorakhpur and Bahraich districts.

Soils of both western and eastern Tarai are productive and possessing initial reserves of plant nutrient specially the nitrogen which gets depleted within few years of intensive cultivation. They are ideally suited for relay or multiple farming. Balanced doses of fertilizers are most responsive in these areas.

Bundelkhand Soils

Bundelkhand lies on the southwest of the river Yamuna. The soils of the tract are entirely different from those of the State as a whole, since these differ geologically from the rest is being non-alluvial in nature. This tract constitutes about 10.85 per cent of the total area of the State and comprises the districts of Jhansi, Jalaun, Hamirpur and Banda. The soils have developed from the Vindhyan rocks abounding in gneiss and granites of the Deccan trap with highly ferruginous beds and often soft limestone.

Four broad soil associations have been recognized in this area, differing from each other in respect of colour, texture, parent material, depth and crop adoptability. These have been named as: (i) Bundelkhand coarse grained reddish brown soils, (ii) Bundelkhand coarse grained grey to greyish brown, (iii) Bundelkhand clayey loam black, and (iv) Bundelkhand clayey black soils which are distinguishable in local paralance by the names of <u>rakar</u>, <u>parwa</u>, <u>kabar</u> and <u>mar</u>.

In general, the agriculture of this tract is of a very low status. This is due to the poor nature of the soil and scarcity of water, these two important factors are responsible for this condition. Most of the cultivation is done during the <u>kharif</u>, while <u>rabi</u> cultivation is insignificant, except on good black soil. Jowar, small millets, and til are the principal <u>kharif</u> crops, and wheat, gram, and linseed are the principal <u>rabi</u> crops. Wheat and jowar are generally grown on better soils, and gram and smaller millets on the soils of lesser fertility.[3]

The soils of Bundelkhand region have generally normal reaction and soluble salt contents. The soils of Jhansi and Banda districts can be classed in low category with respect to available phosphorus content, while that of Jalaun and Hamirpur in the medium category. All the four districts in Bundelkhand have low to medium available potash

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3. Raychaudhary, S.P., et al., <u>Soils of India</u> (New Delhi, 1963), p.332.

contents. Organic carbon status in this area is predominately of moderate category.

The natural vegetations of the area are shrubs and grasses, both tall and small ones. The soils are shallow and the parent rock is met within a depth of half to two metres. Balanced manurings are the most effective practices for optimum growth of crops.

Vindhayan Soils

These soils are residual in origin and occur in the State south of the river Ganga as to comprise the districts of Mirzapur, Varanasi and Allahabad, and cover an area not exceeding more than 5 per cent of the State's total area. These soils have developed on the decomposition products of the sub-adjacent rocks of the Vindhayan system. The soils of the region are broadly classified on the basis of their topography into three categories: (i) Vindhayan uplands, (ii) Vindhayan flats, and (iii) Vindhayan lowlands.

The Vindhayan uplands occupy high-level sites and are basically alluvial in nature being formed under excessive drainage. These soils are coarse grained, red and very shallow, poor in nutrients, resulting in sparse cultivation.

The Vindhayan flats soils have developed on flats having relatively poor drainage conditions. These soils contain more finer-grained material, the profiles are deeper and exibit better moisture conditions than those of uplands.

The Vindhayan lowlands soils are associated with low-level sites and are consequently alluvial in character. These tracts constitute the most fertile portion of the districts which excessively grow rice.

Aravali Soils

This type of soils occur only to an insignificant proportion in southwestern corner of Agra district in Khairharh and Kiroli tehsils, adjoining outer spurs of Central Indian Hills at Bharatpur and Dholpur in the State of Rajasthan. The area under this type of soil in Uttar Pradesh is only 0.21 per cent of the total area (Table II).

These soils have been developed from various formations of Vindhayan sand stones including Kaimur group as the lowest member and Bhandar group as the highest. They are found in an advanced stage of disintegration having a thick soil material, but intermixed with undecomposed fragments of sand stones. These soils are coarse gravelly sands or even loamy sands depending on their location and topography. They are gravelly and are known in local parlance as 'Bhur'. The soils support scanty cultivation and where inferior grains are grown.

Alluvial Soils

Alluvial soils constitute the most extensive soil formation of the State, accounting for 61.78 per cent of its total area. They occur in the central, eastern, western and the southern portions of the State with river Yamuna as its western and southwestern boundary for most of its expanse with the exception of a portion of Agra and Mathura districts, and river Gandak as its eastern boundary separating it from the State of Bihar. These soils have developed from the alluvium deposited by the two rivers Ganga and Yamuna, and their tributaries including Ghaghara, Gandak, Gomti and Ramganga.

Although the nature of the soils in alluvial areas differs widely from district to district , they have been broadly classified into a number of soil associations, named on the basis of the river family which has contributed to the deposition and development of soils in various districts. The soil associations recognised in each district in a particular river system comprise (i) riverine soils or the khadars, (ii) soils of flat lands, (iii) soils of uplands,

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and (iv) soils of low lands. Although variations in soil characters from district to district are very wide, but the broad zonal features of these associations remain more or less the same. Soils comprising the recent alluviums are accordingly grey to ash grey in colour, light textured and of calcareous nature. The flat land soils are accordingly neutral to moderately alkaline and calcareous with accumulation of lime in the form of lime concretions at varying depths and sizes in lower layers of thesoil profile. Soils of uplands exhibit most of the zonal characters, and the profile shows all the evidence of maturity. Low land soils are found in numerous pockets within the upland regions and have been formed from the washing of the finer material transported from the upland areas. The soils are grey to dark grey in colour, and clay loam to clay in texture.

The soils of Gangetic family differ from those of Yamuna family in morphological features of the soil profile as well as agricultural behaviour resulting primarily in the difference of parent material in the two formations. These differences have originated from the regions where the two rivers flow. Ganga covering a wide range of Himalayan rocks while the Yamuna flows for a considerable distance in the region predominating in basaltic rocks in Central Indian

Hills, through the outer spurs of which Yamuna flows in southwest Uttar Pradesh. The recent alluviums of this family are accordingly black coloured, and are of very fine texture, the soil profile shows a marked uniformity at all depths.

Alluvium found in the northeastern tract of Uttar Pradesh is laid down by the rivers Gandak and Ghaghara, the tributaries of Ganga, though following the same pattern of soil development in bottom lands, flats and uplands genetically differ from the soils of the Ganga plains, specially in respect of parent materials which is generally very highly calcareous and in an advanced stage of mechanical disintigration.

The alluvia on the left banks of the Ganga owe their origin to the alluvial material laid down by its tributary Gomti. The soil formation in this family is more or less similar in nature to that of Ganga, differing only in the degree of maturity.

In view of the fertility status, the soils of the alluvial tract almost in all thedistricts of northern region has normal P^H values except, in Bijnor district where slightly acidic soils are also met with. The salt content in the soil in all these districts is normal with no problem of soil salanity. Available phosphorus and potash contents are low in all the districts except, in Bijnor where soils are moderate containing phosphorus and potash. Organic carbon is low in all the districts with the exception of Bareilly and Rampur where it is moderate. With the exception of Aligarh district, the soil reaction of more than 80 per cent soils is in normal range. A very significant proportion of soils in Aligarh district are alkaline in reaction and are fraught with danger of soil salanity. All the districts except of Muzaffarnagar, have low concentration of available phosphorus and potash content. Organic carbon levels are universally low in this region, the least being in the soils of Agra district. In the central region the soils have normal reaction except in the districts of Farrukhabad, Lucknow, Kanpur and Unnao. Alkaline soils are more common in the districts of Farrukhabad, Lucknow, Kanpur and Unnao. Soluble salt contents are normal in all districts except, Unnao, Hardoi and Rae Bareli where 10 to 26 per cent soils have shown critical levels of salt concentration. Potassium status in these soils is medium and all the districts have shown lower concentration of organic carbon. Soils of eastern districts have generally a normal reaction, but the soils in Allahabad, Azamgarh, Ballia and Pratapgarh districts exibit moderate alkalinity. The salt concentration in the soils of these districts is found to be normal. The soils are deficient in available phosphorus status in all the districts except, in Deoria, Gonda, Basti and Gorakhpur districts. The soils in these districts have moderate available potash status. Soils of these districts are poor in organic matter except, the district of Gonda where the soils have medium level of organic carbon. Soils of Pratapgarh district are on the border line between low and medium categorios of organic carbon.

Agriculturally the alluvial soils of Uttar Pradesh are highly productive and constitute one of the most fertile formation of the country. They have immense potentials for increasing crop productions and it is from these soils that the agricultural production levels have lately be achieved by adopting high yielding varieties of seeds and improved practices of cultivation.

Intrazonal Soils

Within the zonal group of alluvial soils two important intrazonal categories of soils have been recognized in Uttar Pradesh. These include: (i) saline alkaline soils, and (ii) karail soils. These two types of soils have been developed due to local influences, mainly hydrological, climatic and halomorphic.

(i) Saline Alkali Soils

These soils are found all along the alluvial region but mainly in central and northwestern portion of Ganga-Yamuna

Doab including a very significant concentration on the left side of Ganga. The greatest concentration of such soils are found in the districts of Meerut, Bulandshahr, Mainpuri, Aligarh, Etah, Farrukhabad, Etawah, Kanpur, Unnao, Fatehpur, Allahabad, Rae Bareli, Lucknow, Pratapgarh, Sultanpur and Hardoi. Even the districts of Azamgarh and Varanasi which are located under relatively less arid climate could not scape the hazards of soil salinization. The factors which have contributed to the formations of this group of soils are the parent material, climate, topography and the drainage. The parent material of this group of soil comprises the alluvial deposits in riverine areas forming saline soils and finely washed material accumulated in the depressions within the zonal tract or innumerable low lying pockets within the landscape of the alluvial regions.

The soils have been commonly categorized into saline soils, saline alkali and non-saline alkali soils. More common category of intrazonal soils in this State is of saline alkali type which occurs in large or small blocks with extensive deposition of salts on the surface during dry months.

(ii) <u>Karail Soils</u>

The black coloured and very fine textured Karail soils occur in the Ganga valley below the point of confluence of Yamuna with Ganga in southeastern part in the district of

Allahabad, Mirzapur, Varanasi, Ghazipur and Ballia. Extensive patches of such tracts are usually found in the deep interior of the region where the river forms circular loop like bends in its course. Closely related black soils are also found in the higher reaches of the alluvial plains principally in the water sheds of Yamuna, even in the districts of Aligarh, Etawah, Kanpur and Fatehpur from the alluvial material transported by the river Yamuna.

Three groups of soils have been recognised in this formation; light shallow Karail soils, deep medium Karail soils, and deep heavy karail soils, which occur respectively in khadar, trans-khadar and lowland tracts of the region adjacent to the course of Ganga below the point of its confluence with Yamuna.

These soils are composed of black heavy clays of considerable depths underlain by coarser alluvial material. The soils have cloddy or prismatic structure, cracking on the surface in dry months and occasionally forming big fissures throught the vertical column of the soil profile. They swell on getting wet and become extremely sticky. Ploughing of these soils present colossal problems to the farmers, principally due to their physical characteristics in which they dry or swell during summer months and any delay or advanced handling makes the tillage operations in these areas almost impossible. The problems get worsen during *kharif* season when the soils become extremely plastic in nature and cannot be tilled.

PART II

THE CONCEPTS AND METHODOLOGICAL FRAME

CHAPTER IV

THE CONCEPT OF AGRICULTURAL PRODUCTIVITY

Before reviewing the methodological procedure of agricultural productivity it would be worthwhile to elucidate the concept of productivity and to clarify a number of questions associated with it and its measurement.

Productivity is not a synonym of 'fertility'. It is generally used to express the power of agriculture in a particular region to produce crops without regard to whether that power is due to the bounty of nature or the efforts of man. On the other hand, fertility denotes the ability of soil to provide all the essential plant nutrients in available form and in a suitable balance for the plant growth.

In recent years many attempts have been made to define the connotation of agricultural productivity, and a considerable amount of literature exists on this subject.[1]

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1. Dovring, F., Productivity of Labour in Agricultural Production, Agricultural Experiment Station Bulletin No.726, College of Agriculture, Urbana, University of Illinois, 1967.---Dursot, D.D. and Barton, G.T., Changing Sources of Farm Output, Production Research Report No.36, USDA, Agricultural Research Service, Washington D.C. 1960.---Horring, J., Concept of Productivity Measurement on a National Scale, OECD, Documentation in Food and Agriculture No.27, Paris, 1964.--- Kendrick, J.W., Productivity Trends in United States, General Series 71, Princenton National Bureau of Economic Research, 1961.---.

(Contd...)

Agricultural productivity may be defined as the ratio of the index of total agricultural output to the index of total input used in farm production. Agricultural productivity is therefore,a measure of the efficiency with which inputs are utilized in production, other things being equal. According to Dewett, "Productivity express the varying relationship between agricultural output and one of the major inputs like, land or labour or capital, other complementary factors remaining the same..." It may be born in mind, that productivity is physical rather than a value concept.[2] The connotation of the torm productivity engaged the attention of many an economist at the 23rd Annual Conference of the Indian Society of Agricultural Economics.[3] Some economists suggested that, the yield per acre should be

(Reference 1 contd.)

Loomis, R.A.,and Barton, G.T., Productivity of Agriculture in the United States 1870-1958, Technical Bulletin 1238, USDA, Agricultural Research Service, Washington, D.C., 1961.--- The State of Food and Agriculture, F.A.O., Rome, 1963.--- Hayami, Y. and Ruttan, V.W., Agricultural Productivity Differences Among Countries, The American Economic Review, Vol.60, No.5, 1970.--- Shishido, T., Japanese Agriculture: Productivity Trend and Development of Technique, Journal of Farm Economics, Vol.43, 1961. Van den Noort, P.C., Agricultural Productivity in Western Europe, Netherlands Journal of Agricultural Science, Vol.15, No.2, 1967.--- Symposium on Measurement of Agricultural Productivity, Journal of Indian Society of Agricultural Statistics, Vol.17, No.2, 1965.--- Regional Variations in Agricultural Development and Productivity, Indian Journal of Agricultural Economics, Vol.19, 1964.--- Productivity, Special Issue on Agricultural Productivity, National Productivity Council Journal, Vol.6, Nos.2&3, 1965.

2. Dewett, K.K. and Singh, G., Indian Economics (Delhi, 1966), p.66.
3. For thorough discussion on this issue see the topic, "Regional Variations in Agricultural Development and Productivity, Indian Journal of Agricultural Economics, Vol.XIX, No.1, 1964, pp.168-266.

considered to indicate agricultural productivity. A number of objections were raised against this view because it considered only land which is just one factor of production while other factors are also responsible for the same. Another suggestion was to consider the returns per unit of the scarce resource to present agricultural productivity. It was pointed out, that the average returns per unit of scarce resource does not depict the true picture, therefore, instead of it, the marginal returns per unit of the scarce resource should be considered. This definition appears to be more meaningful than others, but gives rise to a lot of practical difficulties.

After a thorough discussion, it was generally agreed, that the yield per acre may be considered to represent the agricultural productivity in a particular region, and that other factors of production be considered as the possible causes for the variation while comparing it with the other regions.[4] Pandit, stated the connotation of productivity in these words, "Productivity is defined in economics as the output per unit of input... the art of securing an increase in output from the same input or of getting the same output from a smaller input."[5] He further

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4. See the summary of group discussion, Regional Variations in Agricultural Development and Productivity, op. cit., pp.263-66.
5. Pandit, A.D., Application of Productivity Concept to Indian Agriculture, <u>Productivity</u>, Special Issue on Agricultural Productivity, Vol.6, Nos. 2 and 3, 1965, p.187.

suggests, that increases in productivity, whether in industry or agriculture, is generally the result of a more efficient use of some or of all the factors of production, viz., land, labour, and capital. According to Saxon, basically, productivity is a physical relationship between output and the input which gives rise to that output.[6] Horring, defines the term productivity, that it is generally use rather broadly to denote the ratio of output to any or all associated inputs, in real term.[7]

There are different other concepts of productivity, and still more ways for computing it. The Chairman, of the International Commission on Agricultural Typology, Prof. Kostrowicki, attempted to invite different views on this problem and sent a questionare to over 100 scholars throughout the world, which embodied the following two questions:

1. What methods, of measuring intensity of agriculture should be applied in typological studies of various orders?
2. What methods, measures and indices should be used to define land, labour and capital productivity of agriculture in typological studies of various orders?

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6. Saxon, E.A., Special Concepts of Productivity, ibid, p.226.
7. Horring, J., Concept of Productivity Measurement on a National Scale, OECD, Documentation in Food and Agriculture No.27, Paris, 1964, p.10.

About fifty geographers from all over the world responded and suggested various approaches to the measurement of agricultural intensity and productivity. The opinion of some of them are given in the Appendix II. The Chairman of the Commission while evaluating the different views pointed out, that a special study testing various methods and techniques to be used in the studies of various scales were needed.[8]

Productivity of agriculture so far has been looked from different points of view, such as productivity of land, labour and of capital. These are the best known partial productivity ratios.

Attention may specially be focussed on the productivity of land, because it is the most permanent and fixed among the three conventional categories of inputs (land, labour and capital), and in recent times has assumed special importance with the population explosions. Land on regional or unit basis expresses yield of crops in terms of output, and from a national point of view, it is desirable to secure the employment of a greatest number of persons.

Whereas, the productivity of land is of primary importance as a determinant of the total level of food and

8. Unpublished proceedings of the International Commission on Agricultural Typology, Warsaw, 1966.

agricultural production, the productivity of labour is mainly important as a determinant of the income of the population engaged in agriculture. Labour productivity in agriculture has two important aspects. First, it profoundly affects national prosperity i.e., the national income; secondly, it principally determines the standard of living of the agricultural population.[9] National prosperity in the economic perspective is largely synonymous with the high output per man hour. Therefore, if a country intended to increase its prosperity it needs: (a) to encourage technical assistance and improvements to the labour population, which help to increase productivity in the agricultural economy, and (b) to stimulate a continual transfer of labour from low productivity to high productivity regions. So far as raising the farmer's standard of living is concerned, there are two ways, either he may be paid more than the prevailing world prices for a given amount of work, or the steps can be encountered to raise his output e.g., productivity from the same resources. Output per man can be improved in the agricultural economy:[10] (i) by giving each farm worker more land and livestock to look-after, and (ii) by making each unit of land and livestock capable of yielding a bigger output.

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9. Yates, P.L., Food Land and Manpower in Western Europe (London, 1960), p.149.
10. ibid., p.153.

Productivity measures of capital are particularly complicated to compute and difficult to interpret. This is largely because of both diversity of farms, and forms in which capital may be utilized in agricultural purposes in the production process. It is generally utilized for the purchase of land, for land improvement, land reclamation, drainage, irrigation purposes, livestock purchase, feeds, seeds, fertilizers, agricultural implements and machinery, crop protection chemicals etc.

Measurement of agricultural productivity depends upon conceptually consistent measures of aggregate agricultural output and input. The concept of inputs in productivity studies includes the resources committed to agriculture by the farmers. These inputs are subjected to control by the decisions of the farmers under the framework of government's policies. And, these inputs may be classified as labour and tangible capital (including intermediate products which are purchased annually from the nonfarm sources, such as fertilizer and processed feed and seed). Land, building, machinery, pesticide, livestock and purchased production services are tangible capital inputs. Choice of inputs mainly determines the increases in agricultural productivity depending upon the qualities of inputs in a relative sense, the techniques and skills which are utilized in production process.

Prof. Stamp, while attempting to measure crop productivity per unit area emphasized, that areal differences in productivity are the result partly of natural advantages of soil, and partly of farming efficiency.[11] Farming efficiency, refers to the properties and qualities of various inputs, the manner in which they are combined and utilized in production.

In tho United States, various hypothesises about the causes of increase in agricultural productivity have be advanced. For instance, Henry,[12] in The American Experience has mentioned, that it is primarily the result of an unusual abundance of land and natural resources. Loomis and Barton,[13] suggested that, real causes of increased in productivity have been, 'new knowledge and technical change, and 'such closely related forces as changing relative prices, increased specialization, increased size of farm operation, changes in institutional structure of education, credit, transportation, processing and the economic activity etc.'

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11. Stamp, L.D., Our Developing World (London, 1960) p.108.
12. Henry, B.P., The American Experience, (New York, 1947), p.8.
13. Loomis, R.A. and Barton, G.T., Productivity of Agriculture in the United States 1870-1958, Technical Bulletin 1238, USDA, Agricultural Research Service, Washington, D.C., 1961, p.1.

CHAPTER V

APPROACHES TO THE MEASUREMENT OF AGRICULTURAL PRODUCTIVITY

The assessment of agricultural productivity has engaged the attention of scholars in various fields: geographers, economists, and agricultural scientists for a long time. Attempts have been made to measure and quantify agricultural productivity in India as well as in other countries of the world.

Thompson[1] (1926), while measuring the relative productivity of British and Danish farming emphasized and expressed it in terms of gross output of crops, and livestock. He has considered the following parameters to examine productivity: (i) the yield per acre of crops, (ii) the livestock per 100 acres, (iii) the gross production or output per 100 acres; (iv) the proportion of arable land, (v) the number of persons employed, (vi) the cost of production expressed in terms of wages and labour costs, rent or interest, and (vii) prices, relative profitability and general economic conditions.

Kendall[2] (1939), treated it as a mathematical problem and initiated a system of four coefficients - a

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1. Thompson, R.J., "The Productivity of British and Danish Farming", Journal of the Royal Statistical Society, Vol.LXXXIX, Part II, 1926, p.218.
2. Kendall, M.G., "The Geographical Distribution of Crop Productivity in England", Journal of the Royal Statistical Society, Vol.162, 1939, pp.21-48.

productivity coefficient, a ranking coefficient, a money value coefficient, and a starch equivalent or energy coefficient. The second of these, the ranking coefficient does not involves the use of higher mathematics, and the purpose of which is to arrange in sequence any given number of units growing the same range of crop and then assess their agricultural efficiency.[3] He took the acre yields of ten leading crops in each of the forty-eight administrative counties of England for four selected years. The places occupied by each county in respect to the selected crops were then averaged, and thus ranking coefficient of agricultural efficiency of each county was obtained. If a county was at the top of every list, it would have a ranking coefficient of one and if it were at the bottom of every list, it would have a ranking coefficient equal to the number of counties concerned.

Ganguli[4] (1938), presented a theoretical discussion for computing productivity in agriculture. Firstly, he took into account the area under any crop A, in a particular unit area belonging to a certain region. This area is expressed as a proportion of the total cropped area under all the selected crops. Secondly, he tried to obtain the

3. Terms productivity and efficiency are used synonymously here.
4. Ganguli, B.N., Trends of Agriculture and Population in the Ganges Valley (London, 1938), p.93.

index number of yield. This is found by dividing the yield per hectare of the crop A in that unit by the corresponding yield per hectare for the entire region as the standard. This yield may be expressed as a percentage and the percentage may be regarded as the index number of yield. Thirdly, the proportion of the area under A and the corresponding index number of yield were multiplied. There are two advantages which come to light by using this formula i.e., (a) The relative importance of the crop A in that unit of study is assessed (as indicated by the proportion of the cropped area which is under A), and (b) The yield of the crop A in comparison with the regional standard. The product thus obtained indicates actually an index of the contribution of the crop A to the productivity of the unit considered.

Hirsch[5] (1943), has suggested, 'Crop Yield Index' as the basis of productivity measurement. It expresses the average of the yields of various crops on a farm or in a locality relative to the yields of the same crops on another farm in a second locality. Zobel[6] (1950), has attempted to determine the labour productivity. He considered productivity of labour as the ratio of total output to the total man-hours

5. Hirsch, H.G., "Crop Yield Index", Journal of Farm Economics, Vol.XXV, No.3, 1943, p.583.
6. Zobel, S.P., "On the Measurement of Productivity of Labor", Journal of American Statistical Society, Vol.45, 1950, p.218.

consumed in the production of that output resulting in output per man-hour. This has been designed with the equation:

$$\pi = f(P, L)$$

where

π = productivity of labour, P = production, and
L = labour utilized.

Stamp[7] (1952 and 1960), adopted, the ranking coefficient technique of Kendall, and applied on an international basis in order to determine agricultural efficiency of a number of countries as well as some major crops. Huntington and Valkenburg[8] (1952), considered the measurement of productivity of land on the basis of eight very widely raised crops in Europe. They selected average yield per acre of each crop for Europe as a whole, and assumed as an index of 100 for it. Thus, they calculated the specific yield index of each country accordingly.

Stamp[9] (1958), suggested another method for measuring the agricultural productivity i.e., to convert the total agricultural production in calories. The caloric intake

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7. Stamp, L.D., "The Measurement of Agricultural Efficiency with Special Reference to India", Silver Jublee Souvener Volume, Indian Geographical Society, 1952, pp.177-78.
8. Valkenburg, S.V. and Held, C.C., Europe, New York, 1952, p.102.
9. Stamp, L.D., "The Measurement of Land Resources", The Geographical Review, Vol.48, No.1, 1958, pp.110-16.

is a measure of the general health of a person because it determines the amount of heat and energy needed by the human body. The British Medical Association on the basis of exhaustive enquiry published a table showing a range of desirable caloric intake among adults from 2100 calories a day for a woman in sedentary occupation to 4250 calories for a man engaged in active manual work. For children, the desirable intake is calculated as 800 calories a day, for infants under one year to 3400 calories for teen-age boys.[10] Taking into consideration the age structure of the population the range of occupation, the weight and height of the people living under climatic conditions of northwestern Europe, the average is 2460 calories a day or about 900,000 calories per year. Stamp, called it as a 'Standard Nutrition Unit'. Shafi[11] (1960), applied the technique 'ranking coefficient' of Kendall for measuring the agricultural efficiency in Uttar Pradesh, taking into account eight food crops grown in each of the fortyeight districts of the State. He applied the method to acre yield figures for the two quinquennial years ending 1952 and 1957.

Loomis, and Barton[12] (1961), have measured United States agricultural input and productivity in the aggregate.

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10. Ministry of Agriculture, Fisheries and Food, Manual of Nutrition (London, 1955).
11. Shafi, M., "Measurement of Agricultural Efficiency in Uttar Pradesh", Economic Geography, Vol.36, No.4, 1960, pp.296-305.
12. Loomis, R.A. and Barton, G.T., Productivity of Agriculture United States 1870-1958, Technical Bulletin No.1238, USDA, Washington, D.C., 1961, p.1.

To them, aggregate productivity depends upon conceptually consistent measures of agricultural output and input. The measure of inputs includes all production factors that depend directly on the decisions by the farmers. Meiburg, and Brandt[13](1962), have surveyed the earlier indices relating to the United States agricultural output e.g., output per worker and per man-hour, and several other estimates of total productivity. They considered eight indices of agricultural production which cover various phases of the period between 1866-1960. Mackenzie[14](1962), has measured the efficiency of production in Canadian agriculture by using the 'coefficient of output relative to input'. He describes, that this concept is difficult to define and even more difficult to quantify.

Oommen[15](1962), while working out the trends of productivity in agriculture of the State of Kerala (India) has measured productivity on the basis of yield per acre. Enyedi[16](1964), while describing Geographical Types of Agriculture in Hungary, refers to a formula for determining

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13. Meiburg, C.O. and Brandt, K., "Agricultural Productivity in the United States: 1870-1960", Food Research Institute Studies, Vol.III, No.2, 1962, p.64.
14. Mackenzie, W., "The Impact of Technological Change on the Efficiency of Production in Canadian Agriculture, Canadian Journal of Agricultural Economics, Vol.10, No.1, 1962, p.41.
15. Oommen, M.A., "Agricultural Productivity Trends in Kerala", Agricultural Situation in India, Vol.XVII, No.4, 1962, pp.333-36.
16. Enyedi, G.Y., "Geographical Types of Agriculture", Applied Geography in Hungary, Budapest, 1964, p.61.

agricultural productivity. His productivity coefficient would be read thus:

$$\frac{Y}{Yn} : \frac{T}{Tn}$$

where

Y = the total yield of the respective crop in the unit area,

Yn = the total yield of the crop at the national level,

T = total cropped area of the unit,

Tn = total cropped area at the national level.

Horring[17] (1964), has suggested that the concept of productivity is based upon not only on the single relationship between output and input, but rather on the differences between two or more relationships i.e., differences in the same agricultural region or sub-region as between successive periods (in time), and between similar agricultural regions in different countries or regions during the same period (in space). It may also be possible to make comparisons between the trends of productivity for different products between different regions of the national economy or between the agricultural regions and the national economy as a whole.

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17. Horring, J., Concept of Productivity Measurement in Agriculture on a National Scale, OECD, Documentation in Food and Agriculture 57, Paris, 1964, p.10.

The Indian Society of Agricultural Economics, seized the problom and in its journal, viz., Indian Journal of Agricultural Economics published a series of articles under the broad head of - Regional Variations in Agricultural Development and Productivity'.[18] Among the contributors Chaterji, and Maitreya[19](1964), have determined the levels of agricultural development and productivity during 1950-51 to 1957-58 in tho State of West Bengal considering only two principal crops, viz., rice among the food crops, and jute from the cash crops. They utilized the acre yield figures for this purpose. Dhondyal[20](1964), has measured variations in agricultural development and productivity by selecting three representative districts from the three regions of the Uttar Pradesh, while assessing tho role of credit, intensive crop enterprises, and the influence of irrigation water during 1962-63. Garg[21](1964), worked out the trends in agricultural development with respect to, total cropped area, gross irrigated area and foodgrain production in the two districts of Uttar Pradesh, viz., Gorakhpur, representing the eastern region and Meerut from the western region and

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18. Indian Journal of Agricultural Economics, Vol.19, No.1, 1964, pp.168-266.
19. Chaterji, A. and Maitreya, P., "Some Aspects of Regional Variations in Agricultural Productivity and Development in West Bengal", ibid., pp.207-12.
20. Dhondyal, S.P., "Regional Variations in Agricultural Development and Productivity in the Eastern and Western Regions of Uttar Pradesh", ibid.,pp.193-97.
21. Garg, J.S., "Variation Studies in the Agricultural Development and Productivity in the Eastern and Western Regions of Uttar Pradesh", ibid., pp.193-97.

productivity by assessing acreage, production and average yield per acre of three important crops, viz., rice, wheat and sugarcane in the aforesaid two districts of eastern and western regions. The study period, from 1951-52 to 1960-61 i.e., covering the First and Second Five-Year Plans was taken into account. Gopalkrishnan and Ramakrishna[22](1964), have studied in Andhra Pradesh (India), to measure the degree of variation with respect to (a) agricultural output per acre (Rs.), (b) output per head of agricultural population (Rs.), and causes of variations in each district of the State during 1959-60. The variables related to the level of output per acre are selected in each district as follows: normal level of rainfall, percentage of current and old fallows, percentage of area under irrigation, percentage of literacy, percentage of population depending on agriculture, intensity of cropping, percentage of gross value other than food grains and fodder, percentage of area under all crops excluding fodder and foodgrains, density of agricultural population per acre, and percentage of total area under commercial crops including rice. Sancheti[23](1964), has examined the productivity of principal cereals in the dry areas of the Rajasthan State for the two periods starting from 1956-57 to 1958-59, and

22. Gopalkrishnan, M.D. and Ramakrishna, R.T., "Regional Variations in Agricultural Productivity in Andhra Pradesh", ibid., pp.227-36.
23. Sancheti, D.C., "Productivity of Principal Cereals in Dry Areas of Rajasthan", op. cit., pp.202-7.

1959-60 to 1960-61 respectively and the changes occurred therein. He accounted average yield per acre as the basis of productivity assessment.

Sapre and Deshpande[24](1964), have attempted to refine further the Kendall's ranking coefficient method. For this they used 'weighted average of ranks' instead of the simple average ranks. Thus, it incorporates the proportion of the crop (area) to the total cropped area of the district. In order to assess the weighted ranks, the ranking position of a crop is multiplied by the magnitude of it to the total cropped area. For example, an enumeration unit A has rank 5 on the basis of yield for wheat, and wheat occupies 33 per cent of area to the total cropped land; jowar ranks 3, and occupies 16 per cent of area; rice ranks 4, and occupies 30 per cent of the total cropped land. Thus, the weighted average of ranks for different crops would be (5 x 33) + (3 x 16) + (4 x 30) = 333, divided by the sum of the weights as 333/79 = 4.21. Kendall's ranking coefficient should work out as follows 5 + 3 + 4 = 12, divided by the number of crops taken into consideration as 12/3 = 4.

Indian Society of Agricultural Statistics, organised a symposium on the topic, 'Measurement of Agricultural

24. Sapre, S.G. and Deshpande, V.D., "Inter-District Variations in Agricultural Efficiency in Maharashtra State", op. cit., p.243.

Productivity' at the 17th annual conference of the society, held at Jaipur, Rajasthan in 1964. The research papers contributed by different scholars appeared in societie's journal, viz., Journal of the Indian Society of Agricultural Statistics, in the succeeding issue i.e., in 1965. Sarma[25] (1965), while defining the concept of agricultural productivity has suggested various parameters on which it can be measured. According to him, productivity can be considered in relation to land, labour and capital. It can also be considered in terms of overall resources employed in agriculture. In case of commodities like, foodgrains, fruits and vegetables, and sugarcane and edible seeds he suggests, to equate output of these in terms of calories. While considering the other non-food crops, such as, cotton and other fibres, the only common measure being the value which involves the pricing of different products. For evaluating value, farm harvest or wholesale prices have the definite significance. He also emphasises productivity of labour as the basis of productivity measurement in agriculture e.g., the total number of labour force, in order to take into account the intensity of labour, as the number of man-hours worked in agriculture.[26]

Agricultural productivity according to Sarma, can also be measured with respect to all the resources committed

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25. Sarma, J.S., "Measurement of Agricultural Productivity - Concepts, Definitions, etc.," Journal of the Indian Society of Agricultural Statistics, Vol.XVII, No.2, 1965, pp.253-57.
26. ibid., p.254.

to agriculture including all the inputs: land, labour, building, machinery, fertilizers etc. These should be aggregated and compared with the gross output of the entire region.[27] He further suggests, that productivity studies are more useful when they are made over a period of time. Whenever, a comparable series of required data are available, different techniques of time series analysis can be employed. Productivity comparisons might also be made over at different regions or for different crops.[28]

Khusro[29] (1965), has linked productivity measurement with the output per unit of a single input, and output per unit of cost of all inputs in the agricultural production. Saran[30] (1965), has applied Cobb-Douglas, 'Production Function' approach for the measurement of productivity. The common purpose of this function is to express the input/output relationship between several inputs and one output in the agricultural systems. The function takes the following form:

$$Y = ax_1^b \; x_2^c \; x_3^d \; x_4^e \; .....$$

where, x_1, x_2, x_3 and x_4 denote various inputs like; land, labour, capital assets and other working expanses. The values of b, c, d and e represent elasticities of the respective inputs.

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27. ibid., p.254.
28. ibid., p.255.
29. Khusro, A.M., "Measurement of Productivity at Macro and Micro Level", ibid., p.278.
30. Saran, R., "Production Function Approach to the Measurement of Productivity in Agriculture", ibid., p.268.

Tambad[31] (1965 and 1970), has adopted 'Crop Yield Index' technique for measuring agricultural productivity. He explains, that the purpose of this technique is to express the average yield of various crops on a farm or in a region relative to the yield of same crops on an another farm or in a second region. It can be expressed in the equation form as:

$$\text{Crop Yield Index} = \frac{\sum_{i=1}^{n} \frac{yi}{yio} Ai}{\sum_{i=1}^{n} Ai}$$

where

i = 1, 2, 3, ... n are the number of crops on a given unit area or year,

yi = is the yield per acre of crop i, on a given farm area or year,

Ai = is the weightage of crop i, denoted by the area under the crop as a percentage of total cropped area, and

yio = is the average yield per acre of crop i, of the group of farms, region or the base year.

31. Tambad, S.B., "Spatial and Temporal Variations in Agricultural Productivity in Mysore", Indian Journal of Agricultural Economics, Vol.20, 1965, p.41. -- Tambad, S.B., and Patel, K.V., "Crop Yield Index as a Measure of Productivity", Economic and Political Weekly, Vol.V, No.25, 1970, pp.878-79.

Shafi[32] (1965), has assessed the productivity on the basis of labour population engaged in agriculture. According to him, it can be computed by dividing the gross production in any unit area by the number of man-hours or less precisely by the numbers employed in agriculture. In order to assess the productivity on the basis of population engaged in agriculture it can either be obtained by dividing the total production with the number of workers, or a reverse index be applied where the total number of workers per unit of production is assessed.[33]

Agarwal[34] (1965), has suggested, a 'Factorial Approach', while measuring the efficiency in Bastar district of Madhya Pradesh. In this approach, a number of human controlled factors relating to agricultural production as, crop superiority, crop commercialization, crop security, land use intensity and power input have selected excluding the environmental factors.

Buck[35] (1937 and 1967), assessed the agricultural progress in China, adopting the approach of 'Grain Equivalents'. For this, he converted all the agricultural products into

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32. Shafi, M., "Approaches to the Measurement of Agricultural Efficiency", Proceedings of the Summer School in Geography, Naini Tal (unpublished), Aligarh, 1965, p.4.
33. ibid., p.4.
34. Agarwal, P.C., "Measurement of Agricultural Efficiency in Bastar District A Factorial Approach", ibid.,
35. Buck, J.L., Land Utilization in China, Vol.I, Nanking, 1937,

kilograms of grain equivalent in order to select a unit of measure, a kilogram, and whatever kind of grain was predominating the region. A modification in this method was attempted by Clark, and Haswell[36] (1967) by expressing the output in terms of kilograms of 'wheat equivalent' per head of population.

Dovring[37] (1967), has measured the productivity of labour in United States agriculture, in aggregate since 1919 to 1954 as a whole as well as commodity-wise. Bhatia[38] (1967), while assessing the changes and trends in agricultural efficiency during 1953-63 in Uttar Pradesh adopted the Ganguli's[39] method of productivity measurement and has devised a equation which would be read thus:

$$\text{(i)} \quad IYa = \frac{Yc}{Yr} \cdot 100$$

where

IYa = is the yield index of crop a,

Yc = is the average acre yield of crop a in the component unit,

Yr = is the average acre yield of crop a in the entire study area.

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36. Clark, C., and Haswell, M., The Economics of Subsistence Agriculture', (London, 1964), pp.51-52.
37. Dovring, F., Productivity of Labour in Agricultural Production, Agricultural Experiment Station Bulletin No.726, College of Agriculture, Urbana, University of Illinois, Illinois, 1967.
38. Bhatia, S.S., "Spatial Variations Changes and Trends in Agricultural Efficiency in Uttar Pradesh 1953-1963", Indian Journal of Agricultural Economics, Vol.XXII, No.1, 1967, pp.66-80.
39. Ganguli, B.N., op. cit., p.93.

and

$$(ii) \quad Ei = \frac{Iya.\ ca + Iyb.\ cb + \ldots\ldots Iyn.cn}{ca + cb + \ldots\ldots + cn}$$

where

Ei = is the agricultural efficiency index,

Iya, Iyb etc. = are the indices of various crops, and

ca, cb etc. = represent the proportion of crop land devoted to different crops.

Shafi[40] (1967 and 1969), applied Stamp's 'Standard Nutrition Unit' technique for measuring the efficiency of agriculture in India considering district as an area unit and taking into account a number of crops. Noort[41] (1967), considered 'net total productivity' (being the relationship between net product and factor input) as a method for the measurement of field productivity and also to assess comparisons 'in time' or 'in space'. The purpose of this measure is to account changes in labour and capital inputs in agriculture. Shafi[42] (1970), attempted to compute the index of productivity coefficient following the formula of Enyedi[43] for each district of India with regard to twelve food crops.

40. Shafi, M., "Food Production Efficiency and Nutrition in India", The Geographer, Vol.XIV, 1967, pp.23-7. idem, "Can India Support Five Times Her Population", Science Today, Vol.3, 1969, pp.21-27.
41. Van den Noort, P.C., "Agricultural Productivity in Western Europe", Netherlands Journal of Agricultural Science, Vol.15, No.2, 1967, p.116.
42. Shafi, M., Measurement of Food Crop Productivity in India, Presidential Address, Indian Council of Geographers, Indian Science Congress, 1970.
43. Enyedi, G.Y., op. cit., p.61.

Hayami, and Ruttan[44] (1970), accounted agricultural labour productivity differences in Developed Countries (DC's) and of Less Developed Countries (LDC's) for three different periods e.g., 1955 (1952-56 average), 1960 (1957-62 average), and 1965 (1962-66 average) by using Cobb-Douglas, 'Production Function'. They incorporated the independent variables like; land, labour, livestock, fertilizer, machinery, education and technical manpower.

Shafi[45] (1972), attempted to modify Enyedi's, 'Productivity Coefficient Index' as to measure agricultural productivity of Great Indian Plains. In which he incorporated the areal magnitude of the crop concerned. The formula would be read thus:

$$\left(\frac{yw}{t} + \frac{yr}{t} + \frac{ymi}{t} \ldots.n\right) : \left(\frac{Yw}{T} + \frac{Yr}{T} + \frac{Ymi}{T} \ldots.n\right)$$

Or

$$\frac{\sum^{n} y}{t} : \frac{\sum^{n} Y}{T}$$

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44. Hayami, Y., and Ruttan, V.W., "Agricultural Productivity Differences Among Countries", The American Economic Review, Vol.60, No.5, 1970, pp.895-911.
45. Shafi, M.,"Measurement of Agricultural Productivity of the Great Indian Plains", The Geographer, Vol.19, No.1, 1972, pp.4-13.

Singh[46] (1972), has evolved a new technique for the measurement of agricultural efficiency. Which consists the measurement of carrying capacity per unit area in terms of population in relation to output per unit area. The method would be read in the equation form as:

$$\text{(i)} \quad Cp = \frac{Co}{Sn}$$

where

Cp = is the carrying capacity,

Co = is the caloric output

Sn = standard nutrition for ingestion in calories person/annum.

$$\text{(ii)} \quad Iae = \frac{Cpe}{Cpr} \times 100$$

where

Iae = is the index number of agricultural efficiency,

Cpe = is the carrying capacity in terms of population in the component enumeration unit, and

Cpr = is the carrying capacity in the entire region.

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46. Singh, J., A New Technique for Measuring Agricultural Efficiency in Haryana, India, ibid., pp.14-27.

In its 30th Annual Conference the Indian Society of Agricultural Statistics, held at Bhubaneswar (Orrisa), India, discussed some aspects on agricultural productivity in the Indian context.[47] Raheja, et al.,[48] have measured tho impact of high yielding varieties adoption based on data collected under the scheme 'Sample Surveys for Assessment of High Yielding Varieties Programme' during 1973-74, and regional variations in productivity on tho basis of yiold per hectare in India. Singh ot al[49](1977), havo accounted tho level of increase in the yield of different crops during three decadal years i.e., 1950-51, 1960-61, and 1970-71 in each Stato of India, considering the relationship between the output of foodgrains and related inputs like, the application of fertilizer, proportion of aroa sown more than once, and gross irrigated area.

Nangia et al[50](1977), conducted a field study in the village Khandewala, of Haryana Stato. The study takes

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47. Symposium on, "Regional Imbalances and Economic Development with Special Reference to Agriculture", <u>Journal of the Indian Society of Agricultural Statistics</u>, Vol.XXIX, No.1, 1977, pp.109-24.
48. Raheja, S., et al., "Factors Contributing to Regional Variations in Productivity and Adoption of High Yielding Varieties of Major Cereals in India, ibid., pp.112-13.
49. Singh, D., et al., "Crop Productivity Variation in India", ibid., pp.113-15.
50. Nangia, S., et al., Variations in Field Productivity - A Case Study of Khandewala, Haryana, <u>Occasional Papers No.7</u> (Mimeo.), Centre for the Study of Regional Development, Jawaharlal Nehru University, New Delhi, 1977.

into account the productivity levels at different fields of the village in terms of money value during 1974-75 and a number of factors enumerated in three broad categories, viz., environmental, technological, and institutional which hold responsibilities for the productivity variations. Bhalla[51] (1978), has considered output per person on constant average price for measuring productivity of labour in Indian agriculture in order to account nineteen crops for the trienniums 1962-65, and 1970-73 for each district of the country.

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51. Bhalla, G.S., "Spatial Patterns of Agricultural Labour Productivity", Yojana, Vol.XXII, No.3, 1978, pp.9-11.

PART III

THE ANALYTICAL FRAME

CHAPTER VI

PERSPECTIVES ON AGRICULTURE IN UTTAR PRADESH

A number of problems and prospects relating to agriculture may be studied under the following broad heads in the State of Uttar Pradesh.

A. The Problem of Wastelands

The Wasteland Survey and Reclamation Committee of Ministry of Food and Agriculture, Government of India, entrusted with the task of locating the blocks of wasteland, and suggesting suitable reclamation measures has observed the waste lands exist in small sized blocks in the State. Surveys completed in the districts of Kanpur, Fatehpur, Aligarh, parts of Mainpuri and Unnao have estimated about 1.12 lakh hectares.[1] And the soil chemists estimate the total extant of such lands in large sized blocks is more than 2.40 lakh hectares in the entire State. Besides this, about 1.20 million hectares of land are reported to be lying as waste and have been rendered unproductive due to development of alkalinity and salanity in the soil.

Under the alkalinity and salanity process the lands are called 'Usar' and 'Reh'. It is advocated that in the

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1. The Wasteland Survey and Reclamation Committee, <u>Report on Location and Utilization of Wasteland in India</u>, Part X, U.P., Ministry of Food and Agriculture, Government of India, 1962, p.22.

usar areas, soil disintegration occurs due to the replacement of calcium by sodium in the soil complex, and when the usar lands are impregnated with salts, the glistening of white efflorescene on the land surface is known as 'Reh'.

In Uttar Pradesh, the usar areas are largely confined to the Ganga-Yamuna Doab. In Kanpur district about 28,150 hectares of usar lands are reported in Bilhaur tehsil. Here soil is impregnated with salts and white glistening efflorescene is seen all over the surface. In Lucknow district more than 2,232 hoctares of such lands are located only in Lucknow tehsil. Although, irrigation from canal is available, it is non-perinnial.

The reclaimable usar lands in the State have been divided into three categories:[2]

(I) Easily reclaimable, (II) reclaimable with slight difficulty, and (III) reclaimable with moderate difficulty. In the first category, where the water-table even in the rainy season occurs beyond three metres from the surface and the permeability is at least over one cm. per hour and the soil contains less than 40 per cent clay. The lands falling in second category, are those where water-table is greater than three metres during summer months, but within two metres

2. Shafi, M., "The Problems of Wastelands in India", 21st International Geographical Congress, Symposium on Land Use in Developing Countries, Aligarh, 1972, p.64.

during rainy season and the permeability is at least a little over one cm. per hour and where soil has been 40 per cent clayey. Lands belonging to third category, are those where the permanent water-table remains well above three metres, or the soil profile is little permeable due to restriction of kankar pan or indurated clay pan in the sub-soil within two metres. The distribution of soils under I and II categories in each district is shown in Table III. It is pointed out, that all practices in connection with the reclamation of class I and II type of usar lands are to be followed in the establishment of an adequate system of internal drainage either through open drains or tile drains.

TABLE III

Distribution of wastelands in the districts of U.P.

(Area in hectares)

Name of district	Area available in the category		
	I		II
	a	b	
Kanpur	28,154.8	38,346.4	-
Lucknow	2,672.4	-	-
Fatehpur	-	2,708.0	-
Aligarh	-	7,946.8	-
Mainpuri	-	42,868.4	-
Unnao	-	-	100.0
Banda	-	-	106.0
Bijnor	-	-	811.2
Jalaun	-	-	2,329.6
Pilibhit	-	-	3,390.0
Total	30,827.2	1,12,416.8	6,736.8

a- Based on reports of District Collector
b- Based on soil surveys by State Agricultural Department.

The reclaimation of usar soil in Uttar Pradesh has been successfully carried out near Kanpur and Allahabad districts by applying the heavy doses of molasses (10-12 tonnes per acre). The Usar Recla-mation Farm of Government at Chakeri, in Kanpur district started an experiment of reclaimation over an area of about 200 hectares of usar land with low alkali soils by applying organic manure. The entire land has been reclaimed and normal salt-tolerant crops like paddy, and barley are being grown year after year without any additional treatment.[3]

B. Ground Water Resources

The State's Ground Water Investigation Organization has conducted extensive surveys in order to assess the ground water resources in different parts by installing bores at a number of places so as to cover almost all the districts of the State.

Some informations of investigations regarding water level below the surface at certain places representing all the agro-economic regions of the State have been produced in Table IV, and Fig.31 is based on detailed informations collected from Ground Water Sources of Uttar Pradesh, Ground Water Investigation Organization, Lucknow, 1976. The isohyths are plotted by calculating the mean value between

3. Shafi, M., op. cit., p.64.

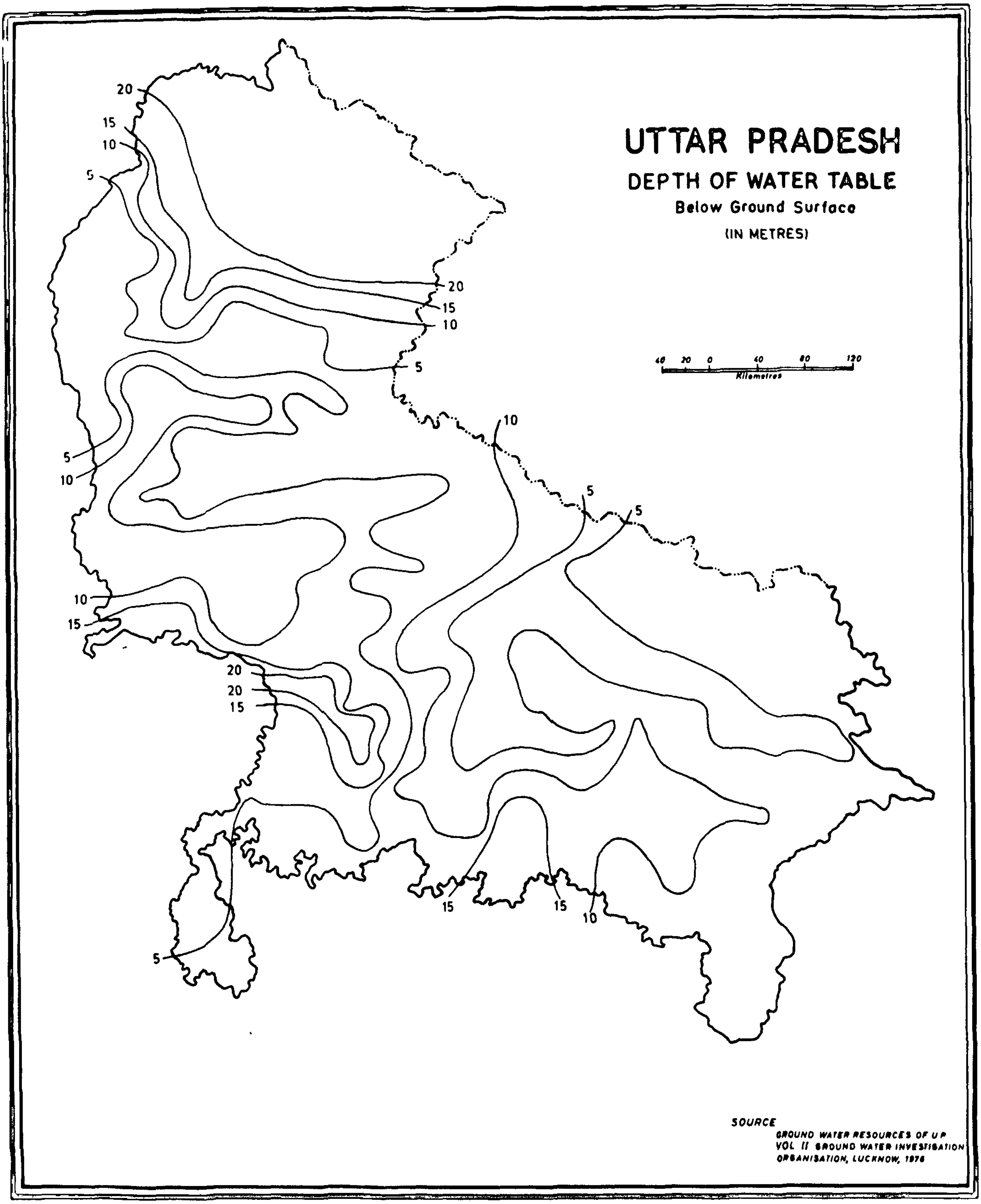
UTTAR PRADESH
DEPTH OF WATER TABLE
Below Ground Surface
(IN METRES)
40 20 0 40 80 120
Kilometres
20
15
10
5
5
10
10
15
20
20
15
5
20
15
10
5
10
5
5
15
15
10
SOURCE
GROUND WATER RESOURCES OF U P
VOL II GROUND WATER INVESTIGATION
ORGANISATION, LUCKNOW, 1976

FIG. 31

two separate months e.g., May and October, for which data are available for the year 1972.

The northern districts comprising the parts of <u>tarai</u> and <u>bhabar</u> regions, viz., Naini Tal and Bijnor

TABLE IV

Depth of water-table at selected places in U.P.

Name of district	Block/Tehsil	Place	Ground water-table below surface (in metres)	
			May	October
Dehra Dun	Doiwala	-	27.45	20.10
Saharanpur	Muzaffarabad	-	3.65	3.60
Mathura	Mathura	-	9.40	8.37
Agra	Firozabad	-	12.45	12.83
Etah	Kasganj	-	5.61	5.75
Mainpuri	Shikohabad	-	4.92	4.59
Etawah	Bidhauna	Sahupur	4.24	4.00
Farrukhabad	Kannauj	Umarda	3.26	1.35
Kanpur	Akbarpur	Shivali	3.34	3.98
Fatehpur	Fatehpur	-	5.00	4.65
Jalaun	Jalaun	-	3.06	2.89
Hamirpur	Hamirpur	-	17.42	14.23
Banda	Banda	-	10.41	10.51
Mirzapur	Mirzapur	Chilbator	12.01	9.80
Faizabad	Bikapur	Patkoli	5.12	2.69
Rae Bareli	Maharajganj	Mohanganj	5.51	4.36
Gorakhpur	Bansgawa	Kousi Ram	6.22	2.96
Deoria	Salempur	Bhagalpur	6.30	2.48
Basti	Harrya	Kopia	3.48	1.65
Gonda	Utrauli	Tactpirva	3.80	3.46

Source: <u>Compiled from Ground Water Sources of U.P.</u>, Vol.II, Ground Water Investigation Organization Uttar Pradesh, Lucknow, 1976.

possess very good ground water potentialities particularly in the southern portions of <u>bhabar</u> belt and the entire <u>tarai</u> belt. It in the <u>bhabar</u> region deep aquifers occur under confined conditions, and in the <u>tarai</u> belt, near the surface ground water is found under unconfined conditions.

There are wide variations in occurrence of ground water-table in both northwestern districts of Dehra Dun and Saharanpur in both the months e.g., May and October. At Doiwala block in district Dehra Dun, the ground water-table recorded in May 27.45 m. and during October 20.10 m. while in Saharanpur district at Muzaffarabad it was in May 3.65 m. and in October 3.60 m. On the eastern side, area between the Chambal and Yamuna comprising the districts of Agra and Mathura is by and large suitable to a depth of about 100 m. for the construction of tube-wells. Here the ground water occurs in Mathura at 9.40 m. in May and 8.37 m. in October, and in Agra district at Firozabad block is 12.45 m. in May and 12.83 m. in October. In the northern parts of Agra district, the ground water found is generally of poor chemical quality. Ground water in the Aligarh district occurs both in confined and non-confined conditions. The water-table in May at Khair block is at 5.48 m. and in October at 3.20 m.

In the three districts of Doab region, viz., Etah, Mainpuri and Etawah the ground water occurs under confined and unconfined conditions. The ground water during May at Kasganj in Etah, at Shikohabad in Mainpuri and Bidhauna in Etawah is recorded as 5.61, 4.92 and 4.24 m., and in October at 5.75, 4.59 and 4.00 m. respectively. In district Farrukhabad the ground water occurs both under water-table and confined conditions. Here at Kannauj block it was recorded at Umarda place as 3.26 m. in May and 1.35 m. during October. The district Kanpur of Doab region is underlained by quarternary alluvium. Near the surface ground water-table occurs here under water-table conditions whereas, in the deeper aquifers it occur under confined conditions. From the hydrological data collected in the Fatehpur district it is easy to observe, that there is a ground water divide between the Ganga and Yamuna catchments, and that the Ganga catchment is more permeable than the Yamuna catchment.[4] The water-table recorded here is as 5.00 m. in May and in October 4.65 m. below ground surface.

The possibilities of ground water development in the Bundelkhand and Vindhyan regions which cover southern parts of the State are rather limited. In Bundelkhand except district of Jalaun, the three districts namely, Jhansi, Hamirpur and Banda are occupied by Bundelkhand granite rock

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4. Report of the Irrigation Commission 1972, Vol.III (Part I), Ministry of Irrigation and Power, New Delhi, pp.45-6.

system, and the alluvium. However, the presence of alluvium in the northern parts of Jhansi district permits to construct tube-wells. In the Jalaun district, the depth of water-table varies at both the tehsils of Jalaun and Kalpi during May 3.06 and 17.56 m., and in October 2.89 and 16.70 m. respectively. A greater part of Mirzapur district is underlained by hard rocks belonging to Vindhyan and Gondwana systems, leaving out a small strip lying in the Gangetic alluvium. Tube-wells drilled in this alluvial strip can yield up to 1,25,000 litres of water per hour. In Mirzapur district the ground water depth recorded at a place Chibator during May as 12.01 m. and in October 9.80 m. below the surface.

The ground water-table in the districts of Azamgarh, Ballia, Jaunpur and Ghazipur in the eastern parts of the State occurs both under water-table and confined conditions. The presence of ground water is suitable for irrigation and heavy duty tube-wells. In Faizabad and Rae Bareli districts near the surface, groundwater occurs in water-table conditions and in deep aquifers under confined conditions. In Faizabad district at Patkoli place of Bikapur tehsil the ground water-table recorded during May as 5.12 m. and in October 2.69 m., and in Rae Bareli at Maharajganj tehsil it was scaled at 5.51 m. in May and 4.36 m. during October.

In the Trans-Ghaghara tract, the water-table in the districts of Deoria and Gorakhpur is influenced by the presence of the Ghaghara and Great Gandak rivers. Therefore, water-table is shallow in the vicinity of the Great Gandak and progressively falls as one goes away from it. The average figures for both the districts show the presence of ground water below the surface during May as 6.22 m. in Gorakhpur at a village Kosi Ram of Banasgawa tehsil in October 2.96 m., and in Deoria district at village Bhagalpur of Salimpur tehsil as 6.30 m. during May and 2.48 m. in October. In Basti and Gonda districts of the same region, the ground water-table occurs under confined and water-table conditions and is fit for irrigation. The water-table figures reported for Basti district at a village Kopia of Harrya tehsil during May are as 3.48 m. and in October 1.65 m., and in Gonda district at Tactpirva of Utrauli tehsil during May as 3.80 m. and in October 3.46 m.

The above discussion clearly shows that most of the areas in the State (except Bundelkhand and Vindhyan regions) have a good scope for the development of ground water resources. In the Bundelkhand region ground water occurs in the fissures and joints of the rocks, therefore, it is tapped by means of large diameter open wells.

C. Size and Number of Holdings

The concept of agricultural holdings envisages the land which wholly or partly is used for agricultural production and is operated by one person- the holder-alone or with the assistance of others, without regard to title, size or location (livestock kept for agricultural purposes without agricultural land is also considered as constituting a holding). Of the 15.16 million holdings in the State 10.10 million (66.64 per cent) are less than one hectare in size. These may be categorized as below marginal. Of the remaining about 5.05 million no less than about 4.51 million (29.79 per cent) are between 1-5 hectares in size, which may be counted as marginal. And the remaining about 0.43 million and 0.11 million holdings (2.83 per cent and 0.73 per cent) respectively are medium between the size of 5-10 hectares and large holdings above 10 hectares. The districtwise details of actual holdings under respective categories have been produced in Appendix III.

The largest concentration of holdings below marginal is in eastern and northeastern districts, where the percentage share of this category ranges between 60 and 70, and in same cases it exceeds upto 80 per cent. For instance, the percentage figures of holdings below one hectare for the districts of Varanasi, Jaunpur and Azamgarh are in order of

80.32, 83.99 and 81.71 respectively (Table V). In the other districts namely, Allahabad, Ghazipur, Ballia, Gorakhpur, Deoria, Basti, Faizabad, Sultanpur, Pratapgarh and Bara Banki the presence of holdings below one hectare is between 70 and 80 per cent. There also a large concentration of holdings below one hectare between the range of 60 and 70 per cent almost in all the districts of Rohilkhand region, three districts of middle Doab namely, Mainpuri, Etah and Etawah. Between the range of 50 and 60 per cent are included the districts of Dehra Dun of sub-Montane tract, Muzaffarnagar, Meerut and Bulandshahr of Doab and one district of Fatehpur of lower Doab. The districts where the holdings below one hectare are concentrated lie in the range of 30-40 per cent and include the whole of Bundelkhand region. Besides this, some other districts show the concentration above 40 per cent.

The number of marginal holdings e.g., 1-5 hectares are restricted almost in all the districts in which the share of small holdings is less than one hectare is high. In fourteen districts of the State, marginal holdings account above 40 per cent and also this range extends upto 50 per cent in some cases. In the remaining districts, sixteen districts have marginal holdings between 30 and 40 per cent (Table V). There are twelve districts where the percentages of marginal holdings are between the figures of 30 and 40. And the remaining other districts possess holdings below 20 per cent.

TABLE V

Percentage share of each category in total holdings in U.P. 1971

Name of district	Below 1 hectare	1-5 hectare	5-10 hectare	Above 10 hectare
1	2	3	4	5
Dehra Dun	65.60	31.40	2.50	0.50
Saharanpur	48.58	42.57	7.22	2.00
Muzaffarnagar	52.33	40.25	6.12	1.83
Meerut	58.62	32.99	4.32	0.72
Bulandshahr	50.48	43.77	4.84	0.89
Aligarh	47.45	45.08	6.39	1.06
Mathura	38.45	50.60	9.22	1.71
Agra	47.52	46.02	5.47	0.97
Mainpuri	69.66	28.25	1.81	0.28
Etah	65.74	31.43	2.42	0.40
Bareilly	62.79	34.57	2.29	0.36
Bijnor	48.31	43.84	6.44	1.42
Budaun	65.12	32.32	2.22	0.34
Moradabad	57.71	38.42	3.35	0.53
Shahjahanpur	67.14	30.47	1.96	0.43
Pilibhit	60.49	36.48	2.30	0.74
Rampur	60.73	36.13	2.51	0.63
Farrukhabad	52.54	45.51	1.67	0.28
Etawah	63.82	33.47	2.34	0.39
Kanpur	43.90	53.38	2.35	0.37
Fatehpur	59.56	35.51	3.98	0.95
Allahabad	70.33	26.11	2.54	1.02
Jhansi	36.96	49.31	10.12	3.62
Jalaun	37.10	47.64	11.24	4.03
Hamirpur	35.50	47.55	11.62	5.33
Banda	45.27	42.18	8.57	3.98
Varanasi	80.32	18.05	1.32	0.31
Mirzapur	59.11	32.96	5.27	2.66

(contd.....)

TABLE V (Contd...)

1	2	3	4	5
Jaunpur	83.99	15.10	0.78	0.13
Ghazipur	72.21	24.91	2.34	0.55
Ballia	74.44	22.78	2.18	0.60
Gorakhpur	75.97	22.24	1.37	0.43
Deoria	75.62	22.62	1.37	0.39
Basti	74.79	23.25	1.55	0.41
Azamgarh	81.71	17.01	1.08	0.22
Naini Tal	36.34	49.32	11.10	3.25
Lucknow	67.28	31.02	1.40	0.31
Unnao	44.85	53.27	1.57	0.31
Rae Bareli	72.34	26.18	1.26	0.22
Sitapur	63.29	34.21	2.06	0.44
Hardoi	65.76	31.90	1.95	0.39
Kheri	60.46	36.00	2.68	0.86
Faizabad	78.87	19.95	1.00	0.18
Gonda	69.75	27.60	2.16	0.48
Bahraich	67.83	29.63	2.05	0.49
Sultanpur	77.99	20.43	1.31	0.26
Pratapgarh	75.87	22.68	1.21	0.25
Bara Banki	73.03	25.52	1.21	0.24
Uttar Pradesh	66.64	29.79	2.83	0.73

The number of medium holdings e.g., 5-10 hectares are further reduced to below marginal and marginal holdings to medium are considered. The highest concentration between

8-12 per cent is found in the district of Mathura and Bundelkhand region. In the percentage of 4 to 8 are included the eight districts of Saharanpur, Muzaffarnagar, Meerut, Bulandshahr, Aligarh and Agra of Doab region, Bijnor of Rohilkhand and Mirzapur from southeastern corner. And, rest of the districts fall within the range of 2 to 4 per cent.

As the numbers of large holdings are only about 0.11 million in the State and these share only 0.73 per cent in the total holdings. Therefore, their concentration is naturally restricted to few pockets. The percentage share of large holdings e.g., more than 10 hectares in different categories of holdings is comparatively high in Bundelkhand districts and in Naini Tal too, where it ranges between 3 and 5. The remaining districts fall below the range of 2 per cent in the State.

It may be summarised, that almost in all the districts the number of agricultural holdings are between the two categories of holding size e.g., below one hectare and 1-5 hectares. These two categories constitute about more than 90 per cent of the holdings. Evidently, the concentration of holdings below one hectare is rather pronounced in districts where land-man ratio is acute.

D. Intensive Cultivation Programmes

A number of schemes and programmes to increase agricultural production have been launched from time to time during the last two decades in different parts of the country. In Uttar Pradesh, the Intensive Cultivation Programmes were initiated at the instance of the Agricultural Production Team, sponsored by the Ford Foundation. The team was of the opinion that there were no inherent soil, climate or other physical reasons for the present low yields and these could be significantly improved through intensive efforts by combining all the technological improvements and by concentrating all the available manpower and other resources in selected areas having the optimum conditions for increasing agricultural production.[5] Therefore, the logic underlying the idea of intensive cultivation programmes is to be that,

> "Inter-related resources and inputs, when applied in strategic combinations yield more than the sum total of the output produced by the same amount of resources applied individually and in isolation with each other".[6]

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5. Intensive Agricultural District Programme Report (1961-63), Expert Committee on Assessment and Evaluation, Ministry of Food and Agriculture, Government of India, 1963, p.1.
6. Singh, H., "Intensive Agricultural Approach to Ag-ricultural Development," Indian Journal of Agricultural Economics, Vol.XXI, No.4, 1966, p.141.

The areas under intensive agricultural approach or in other words, the input intensification approach follows the 'package' concept. In it programmes are selected on the basis of a careful study of their potentials with relatively favourable conditions for agricultural production. These programmes are based on person to person approach, for which the village level workers are asked to prepare appropriate farm plans for individual farms in respect of crops which the farmers have to grow. The farmers also prepare the inventories according to their requirements for crop production. Besides farm demonstrations are also planned to show the cummulative effects of the 'package of inter-related improved inputs and husbandary practices' on yield. Thus, the package approach provides the necessary guidelines for raising the technical levels in agriculture and experience gained in work in certain areas as to stimulate developments in other areas too.

(a) <u>The Intensive Agricultural District Programme</u> (IADP)

This programme was sponsored during 1961-62 as an 'impact programme' with the motives that it would provide the concentration of enough efforts in selected areas to bring about a real 'break-through' in agriculture in India. During the same year the district of Aligarh was selected in the State of Uttar Pradesh with the two-fold objectives of: (i) increasing food production in order to meet the existing shortage as well as to provide base for more rapid economic development, and (ii) demonstrating the most effective ways of increasing food production through the concentration of resources, both human and material by setting a pattern of extending such intensified agricultural programmes to other favourable areas having sufficient irrigation and assured supplies of water. In Aligarh district, this programme covered 12 development blocks, and 196 villages during the year of its inception i.e., 1961-62.[7] Later on it was extended to cover an area of 1.70 lakh hectares out of the total of 6.14 lakh hectares of the cultivated land by 1964-65. In 1965-66 it was proposed to cover 3.48 lakh hectares more involving all the 1.50 lakh families of the said district.[8] Since than, this programme has an encouraging performance in the district.[9] During the year 1970-71 this programme covered an area of 5,41,015 hectares (91.12 per cent) under food crops, out of 5,93,680 hectares as total cropped area in the district (Fig.32).

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7. Agarwal, S.K., "Intensive Cultivation Programmes in Uttar Pradesh- A Retrospect", Indian Journal of Agricultural Economics, op. cit., p.136.
8. ibid., p.136.
9. Krishan, R., Intensive Agriculture Programme Aligarh - The Beacon Light, Directorate of Agriculture, U.P., Lucknow.

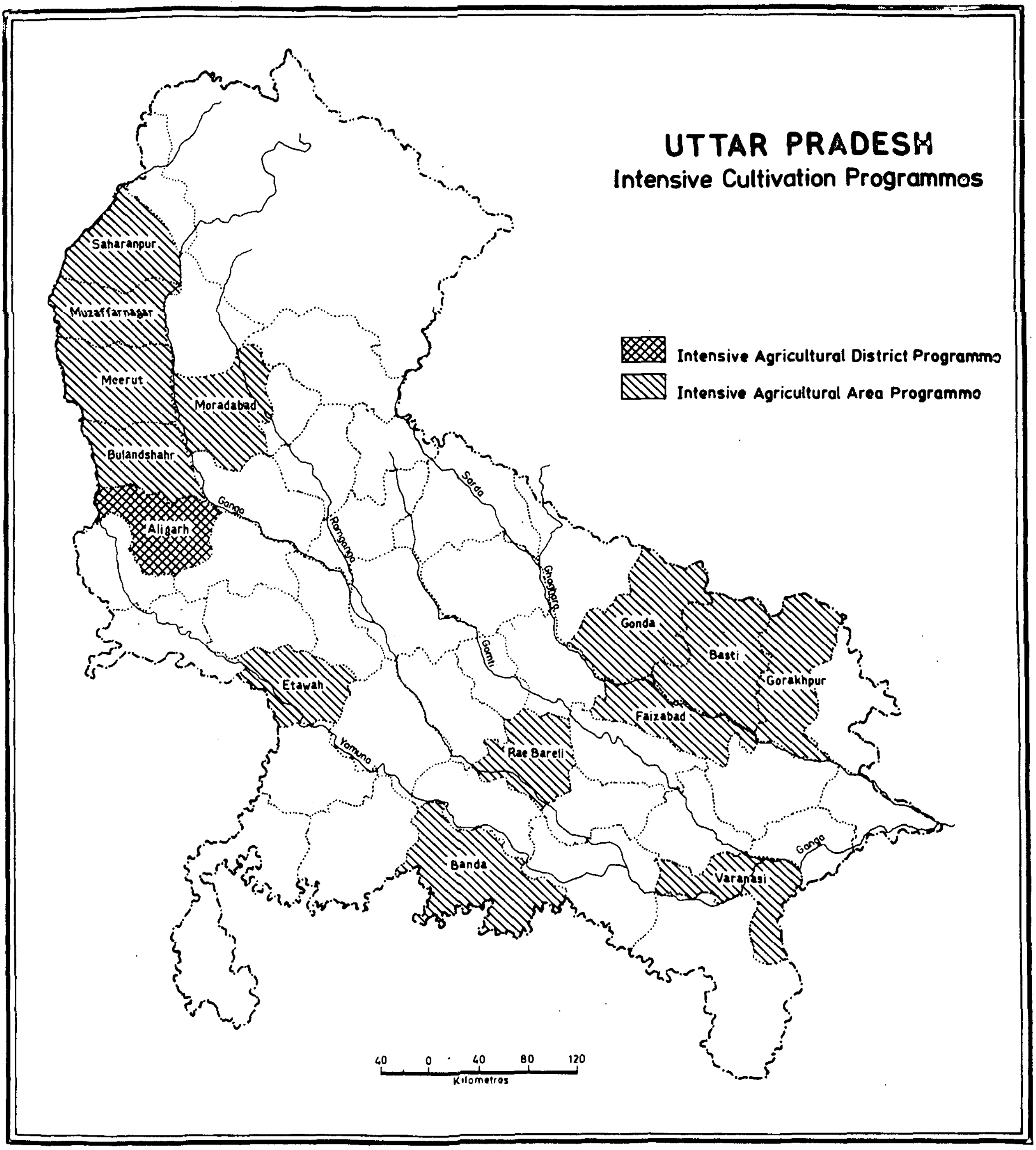
UTTAR PRADESH
Intensive Cultivation Programmes
Intensive Agricultural District Programme
Intensive Agricultural Area Programme
Saharanpur
Muzaffarnagar
Meerut
Moradabad
Bulandshahr
Aligarh
Ganga
Ramganga
Sarda
Ghaghara
Gomti
Gonda
Basti
Gorakhpur
Faizabad
Etawah
Yamuna
Rae Bareli
Banda
Varanasi
40 0 40 80 120
Kilometres

FIG. 32

(b) Intensive Agricultural Area Programme (IAAP)

Based on the experience of package approach, in the subsequent years the Central Government, decided to launch Intensive Agricultural Area Programme, a slightly diluted form of IADP, to increase the production of paddy, wheat, millets and pulses. Accordingly 25 blocks in the districts of Varanasi, Basti, Banda and Saharanpur were selected for enhancing the cultivation of paddy from *kharif* season of 1964-65; 25 blocks in the districts of Meerut, Bulandshahr, Gonda, Faizabad and Muzaffarnagar were selected for augmenting wheat cultivation from *rabi* season of 1964-65; and 92 blocks in the districts of Agra, Jhansi, Etah, Jalaun and Mathura were chosen for the intensive cultivation of millets and pulses.[10] It was proposed that upto 1966-67 (the year in which High-Yielding Varieties Programme was introduced in the State) all the remaining blocks of the selected paddy and wheat cultivation areas would be covered in the State. This was also to include 7 blocks each of the Gorakhpur and Rae Bareli districts.[11] The above districts were selected from the point of view of predominance of a particular crop, but today, the emphasis has been laid on the crop economy as a whole.

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10. Randhawa, M.S., Intensive Cultivation Programme, Farm Information Unit, Directorate of Extention, Ministry of Food and Agriculture, Government of India, 1965, pp. 3 and 5.
11. Agarwal, S.K., op. cit., p.137.

During 1970-71 there were fourteen districts, viz., Saharanpur, Muzaffarnagar, Meerut, Bulandshahr, Aligarh, Moradabad, Etawah, Banda, Varanasi, Gorakhpur, Basti, Rae Bareli, Faizabad and Gonda under intensive cultivation programmes in the State. They accounted 38,049 villages and about 8 million hectares (34.25 per cent) out of about 23.2 million hectares of the State's total cropped area. The proportion of food crops area accounted about 7 million hectares (88.71 per cent) in it (Fig.32).

E. Land Use Profile

Land use records are maintained and classified under the following major categories: (i) Reporting are for land utilization purposes, (ii) Forest, (iii) Barren and unculturable land, (iv) Land put to non-agricultural uses, (v) Culturable waste, (vi) Permanent pastures and other grazing lands, (vii) Land under miscellaneous tree crops and groves not included in net area sown, (viii) Current fallows, (ix) Other fallow lands, (x) Net area sown, (xi) Area sown more than once, and (xii) Total cropped area. Figures relating to the above classification for the State of Uttar Pradesh (Plain portions) are given in Table VI for the three points of time.

During 1970-71 the reporting area for land utilization purposes was estimated about 25.59 million

TABLE VI

Land utilization in Uttar Pradesh (Plain portions) - A trend of progress

Item	1950-51	1960-61	1970-71
Reporting area for land utilization purposes	2,51,44,630	2,53,81,017	2,55,89,169
Forests	12,97,959 (5.16)	19,60,246 (7.72)	22,88,440 (8.94)
Barren and unculturable lands	14,98,162 (7.37)	11,40,161 (7.53)	10,15,591 (7.90)
Land put to non-agricultural uses	18,52,579 (9.19)	19,12,333 (6.46)	20,22,414 (5.36)
Culturable wastes	23,10,732 (9.19)	16,39,523 (6.46)	13,72,820 (5.36)
Permanent pastures and other grazing lands	N.A.	43,806 (0.17)	77,822 (0.30)
Land under miscellaneous tree crops and groves not included in net area sown	12,39,713 (4.93)	7,18,880 (2.83)	6,28,159 (2.45)
Current fallows	10,45,761 (4.16)	10,45,595 (4.12)	7,69,817 (3.01)
Other fallow lands	2,90,525 (1.16)	12,59,668 (4.96)	5,58,023 (2.18)
Net area sown	1,56,09,199 (62.08)	1,65,60,805 (65.25)	1,68,56,083 (65.87)
Area sown more than once	36,49,674 (14.51)	44,63,086 (17.58)	53,15,841 (20.77)
Total cropped area	1,92,58,873 (76.59)	2,10,23,891 (82.83)	2,21,71,924 (86.65)

Note: Figures in parenthesis are the percentages to the reporting area for land utilization purposes.

Source: Bulletin of Agricultural Statistics for U.P. 1970-71, Directorate of Agriculture, U.P., Lucknow.

hectares, of which about 22.17 million hectares (86.65 per cent) reported to be the total cropped area. Out of the total of 25.59 million hectares net sown area accounted about 16.85 million hectares (65.87 per cent). Next to this, area more than once registered as about 5.13 million hectares (20.77 per cent). Area covered under forests reported about 2.29 million hectares (8.94 per cent). Land put to non-agricultural uses reported to be about 2.02 million hectares (7.90 per cent). Culturable wastes covered on area about 1.37 million hectares (5.36 per cent). Area under current fallows accounted as about 0.77 million hectares (3.01 per cent). The remaining three categories in order of, land under miscellaneous tree crops and groves not included in net area sown, other fallow lands, and permanent pastures and other grazing lands accounted as about 0.63 million hectares (2.45 per cent), 0.56 million hectares (2.18 per cent), and 0.07 million hectares (0.30 per cent) respectively.

It can further be observed from the table that, there is a continuous change in respect to reporting area for land utilization purposes (in increasing order), which has increased about 0.23 million hectares between 1950-51 and 1960-61 and of about 0.21 million hectares an additional increase accounted between 1960-61 and 1970-71. The net area sown recorded an increase of about 0.95 million hectares (3.17 per cent) between 1950-51 and 1960-61, and of about

0.28 million hectares (0.62 per cent) between 1960-61 and 1970-71. The area sown more than once shows an increase of about 0.82 million hectares (3.07 per cent) accounted between 1950-51 and 1960-61, and during 1960-61 and 1970-71 area increased about 0.95 million hectares (3.19 per cent). Area under forests has also increased by about 0.66 million hectares (2.56 per cent) between 1950-51 and 1960-61, and about 0.33 million hectares (1.22 per cent) between 1960-61 and 1970-71.

With respect to total cropped area, there seems a significance shift during the corresponding periods. An additional area of about 1.86 million hectares (6.24 per cent) was brought under cultivation between 1950-51 and 1960-61, which further increased to about 1.15 million hectares (3.82 per cent) between 1960-61 and 1970-71.

Besides these, the other categories of land use classification show more or less declining trend. This may have due to the continuous and perfect management practices, which resulted the intensive use of land.

F. Cropping Pattern and Crop Production

In order to analyse the cropping pattern and crop production levels in the State, it would be worthwhile to give some preliminary idea about the crops their sowing and harvesting seasons etc.

As described earlier, that in India there are two main seasons e.g., kharif or the seasons of summer crops and the rabi or the season of winter crops. The sowing in the kharif season begins generally on the onset of southwest monsoon in mid-June, while the rabi season starts at the begining of cold weather i.e., at the end of October or early November when the monsoon has receded. The crops of kharif season are: rice (oryza sativa), jowar (sorgum valgare), bajra (penniselum typhoideum), maize (zea mays), arhar (cajanus indicus), moong (phaseolus aureus roxb), urd (phaseolus mungo), groundnut (arachis hypogea) and sugarcane (sacchasum officinarum) which require a high temperatures and plentiful supply of water, and the crops of rabi season are: wheat (trilicum sativum), barley (hordeum vulgare), gram (cicer arientinum), masur (lens esculenta, also erven lens), peas (pisum sativum) and potato (solavum tubrosum) which require cool weather and moderate supply of water. The harvesting period of kharif crops starts at the end of monsoon i.e., September to October (may continue till November in same cases), and the rabi crops harvested from February to April (may continue till May in some cases) Table VII.

(a) State Levels in Area and Production of Food Crops

Since this study is based on selected food crops, therefore, it is worthwhile to examine their relative position

TABLE VII

Sowing and harvesting seasons of food crops in U.P.

Name of crop	Sowing	Harvesting
Rice	June - August	November-December
Jowar	June - July	October -December
Bajra	June - August	September-November
Maize	June - July	August - October
Wheat	October-December	March - May
Barley	September-November	March - May
Gram	September-November	March - April
Arhar	May - July	December-January
Oilseeds		
(a) Groundnut	May - July	October-December
(b) Castorseed	June - July	January-April
(c) Rapeseed and mustard	September-November	December-May
Sugarcane	September-April	October-June
Potato	September-October	November-February

Source: Compiled from the Estimates of Area and Production of Principal Crops in India 1975-76, Directorate of Economics and Statistics, Government of India, 1977.

with respect to area and production of each of them in the State.

The crops selected are rice, jowar, bajra, maize, wheat, barley, gram, arhar, pulses (including urd, moong, masur and moth), oilseeds (including groundnut, castor, linseed, rapeseed and mustard), sugarcane and potato. Table VII shows a trend of progress of each crop in respect of area, production and yield during 1950-51, 1960-61 and 1970-71 in the State. It is clear from Table VII that there exist little possibility for extending area horizontally under the crop as the situation has already reached a saturation point. As a result, the only measure to raise output from the same piece of land is from its vertical axis. It can be justified from the figures (Table VIII), which show no marked variations in total area devoted under the crops concerned during 1950-51 which is about 17.63 million hectares (91.53 per cent) of the total cropped area, 19.00 million hectares (90.00 per cent) during 1960-61 and about 20.50 million hectares (92.46 per cent) in 1970-71.

Among the individual crops rice, bajra, maize, wheat, oilseeds and sugarcane show an increasing trend (since 1950-51) in area devoted to them. Wheat is the only crop which attained an abrupt shift from about 3.31 million hectares in 1950-51 to 3.75 million hectares in 1960-61 and about

TABLE VIII

Area, production and yield of food crops in U.P. - A trend of progress

Area = thousand hectares
Production = thousand tonnes
Yield = quintals per hectare

Food crops	1950-51			1960-61			1970-71		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Rice	3,852	1,998	5.19	4,020	3,150	7.53	4,417	3,605	8.16
Jowar	941	646	6.86	894	494	5.53	734	485	6.62
Bajra	1,044	672	6.44	1,089	429	3.94	1,120	881	7.87
Maize	833	651	7.81	1,043	625	5.93	1,497	1,798	11.93
Wheat	3,315	2,721	8.21	3,750	3,944	10.01	5,587	7,689	13.02
Barley	1,947	1,712	8.80	1,756	1,687	9.14	1,323	1,430	10.81
Gram	2,439	1,453	5.96	2,552	1,831	7.17	2,077	1,543	7.43
Arhar	647	824	11.50	652	885	13.58	582	678	11.65
Pulses	1,258	N.A.	N.A.	1,332	1,106	8.41	1,053	846	8.24
Oilseeds	258	167	3.61	399	252	3.94	612	365	4.71
Sugarcane	1,013	29,498	291.04	1,328	54,515	410.21	1,345	54,672	406.42
Potato	82	640	78.08	107	799	70.37	155	1,485	92.00
Total	17,629	41,162	-	18,922	69,717	-	20,502	71,477	-

N.A. = Data not available.

Source: 1. Bulletin of Agricultural Statistics for Uttar Pradesh 1970-71, Directorate of Agriculture, U.P. Lucknow.

2. Estimates of Area and Production of Principal Crops in India 1975-76, Directorate of Economics and Statistics, Government of India, 1977.

5.58 million hectares during 1970-71. This shift may be accounted due to the introduction of high-yielding varieties programme in the State between the period 1960-61 and 1970-71. Rice records the second place in area and changes therein being about 3.85 million hectares in 1950-51 to 4.00 million hectares during 1960-61 and about 4.41 million hectares in 1970-71. Maize accounted an increase in area next to rice over a span to two decades i.e., 1950-51 to 1960-61 of about 0.20 million hectares and from 1960-61 to 1970-71 an additional increase of about 0.45 million hectares. Next to maize, bajra shows an increase in slow and gradual order (Table VIII). In case of oilseeds and sugarcane, the increase seems in a gradual order, but oilseeds recorded a sharp increase of about 0.21 million hectares in 1970-71 as compared to 1960-61.

As regard to achievements in crop production the situation is well encouraging. The sugarcane, wheat and rice, these three crops constituted share of about 90 per cent in gross production (1970-71) in the State. The wheat and rice are the staple crops, therefore, the achievements in crop output are well marked, and the inception of high-yielding varieties programme has finally changed the outlook. In 1950-51, wheat was cultivated on about 3.31 million hectares which accounted a production of about 3.75 million tonnes with an average yield of 8.21 quintals per hectare. During

1960-61 the gross production of wheat gone upto about 4.00 million tonnes and the yield rose upto 10 quintals per hectare. In 1970-71 the area under crop concerned increased upto about 5.58 million hectares with a record production of about 7.69 million tonnes, which resulted average yield of 13 quintals per hectare. Rice recorded a production of about 2 million tonnes in 1950-51 with an average yield of 5.19 quintals per hectare. During 1960-61 this crop occupied about 4 million hectares against 3.85 million hectares in 1950-51. The gross production in 1960-61 gone upto 3.15 million tonnes with an average yield of 7.53 quintals per hectare. In 1970-71 the production of rice exhibited a further increase of about 0.45 million tonnes as compared to 1960-61 with an average yield of 8.16 quintals per hectare.

Next to wheat and rice, sugarcane and potato show a change both in respect of area as well as production in the State. The due importance given to them during the course of times seems to be the ready profibility over other crops. The area devoted to sugarcane during 1950-51 was estimated about one million hectares and the gross output recorded about 29 million tonnes. During 1960-61 it rose upto 54 million tonnes, with an increase of about 0.31 million hectares of area put under it. At the same time the average yield also went upto 410 quintals per hectare from 290 quintals as it was in 1950-51. In the year 1970-71 the position remained more or less the same as was estimated during 1960-61. In case of potatoes, during 1950-51 an area of about 0.08 million hectares was devoted to it, which recorded a gross production of 0.64 tonnes of potatoes with an average yield of 78 quintals per hectare. This situation changed during 1960-61 as well as in 1970-71. The crop occupied about 0.10 and 0.15 million hectares in the years 1960-61 and 1970-71 respectively. The gross production shot upto 0.80 and 1.50 million tonnes in the corresponding years. Average yield during 1960-61 shrank and remained only 70.37 quintals per hectare against the yield of crop during 1950-51 as 78 quintals per hectare. But in 1970-71 the yield was about 92 quintals per hectare.

Besides these, the other crops show a gradual decrease in area and in some cases increase in gross production. And in few cases the average yield is affected consequently in order of increase or decrease to a certain extent with this change in area and production. In case of gram, this crop covered about 2.44 million hectares to produce 1.45 million tonnes, with an average yield of about 6 quintals per hectares. Subsequently in 1960-61 this crop occupied about 2.55 million hectares, more than 0.11 million hectares as compared to the figures of previous decennial year with an average yield of 7.17 quintals per hectare. But in 1970-71 the crop covered about 2.07 million hectares, less than

0.47 million hectares as compared to 1960-61. As a result the gross production reduced to 1.50 million tonnes but the average yield was not affected very much being 7.43 quintals per hectare.

(b) Districtwise Variations in Area Under Food Crops

Districtwise and cropwise area is produced in Appendices IV to VI during the three subsequent decennial years i.e. 1950-51, 1960-61 and 1970-71 and their aggregate percentages to the total cropped area, and their relative position in each district are produced in Table IX. And Fig.33 shows the area (in percentages) devoted under crops considered in each district, which have be grouped under certain range for three different points of time. It is easy to observe from the Table IX that there is a continuous increase of area under the crops being about 17.63 million hectares in 1950-51, and during 1960-61 they occupied about 19 million hectares and the area during 1970-71 rose upto more than 20 million hectares. From the districtwise details shown in Table IX can be observed, that the highly intensive areas lying in 1950-51 were in Budaun district of Rohilkhand region, five districts, viz., Mainpuri, Farrukhabad, Etawah, Fatehpur and Kanpur to comprise the middle and lower Doab and to share more than 92.50 per cent area under them. In between the range of 90.50 and 92.50 per cent were the districts of

Mathura, Bulandshahr and Agra of Doab, four districts of Rohilkhand region, viz., Bijnor, Moradabad, Rampur and Bareilly, and two districts of Kheri and Basti comprising the Tarai and Trans-Ghaghara tracts.

Among the four districts of Bundelkhand region namely, Jalaun and Banda roprosent among the highest intensively cultivated parts of the Stato by covering more than 92.50 per cent under food crops to the total cropped area. The remaining districts of northwestern as well as central, eastern and southeastern parts of the State either fall between the range of 85.50-87.50 per cent or less than 85.50 per cent.

During the year 1960-61 the cropping range in general shows a slight increase of about one per cent and except very few pockets of districts, the pattern of crop concentration is more or less unchanged and is comparable with the previous decennial year i.e., 1950-51. The situation during 1970-71 seems to be encouraging in which almost all the districts recorded an overall increase in between the percentages range of area of about 2.50 per cent as compared to the preceding decennial year i.e. 1960-61 (Fig.33).

(c) <u>Rate of Growth in the Area of Food Crops</u>

A further extension in area under the crops considered in the State are rather limited. The crop data

TABLE IX

Districtwise total area under food crops in U.P. - A trend of progress

(Area in hectares)

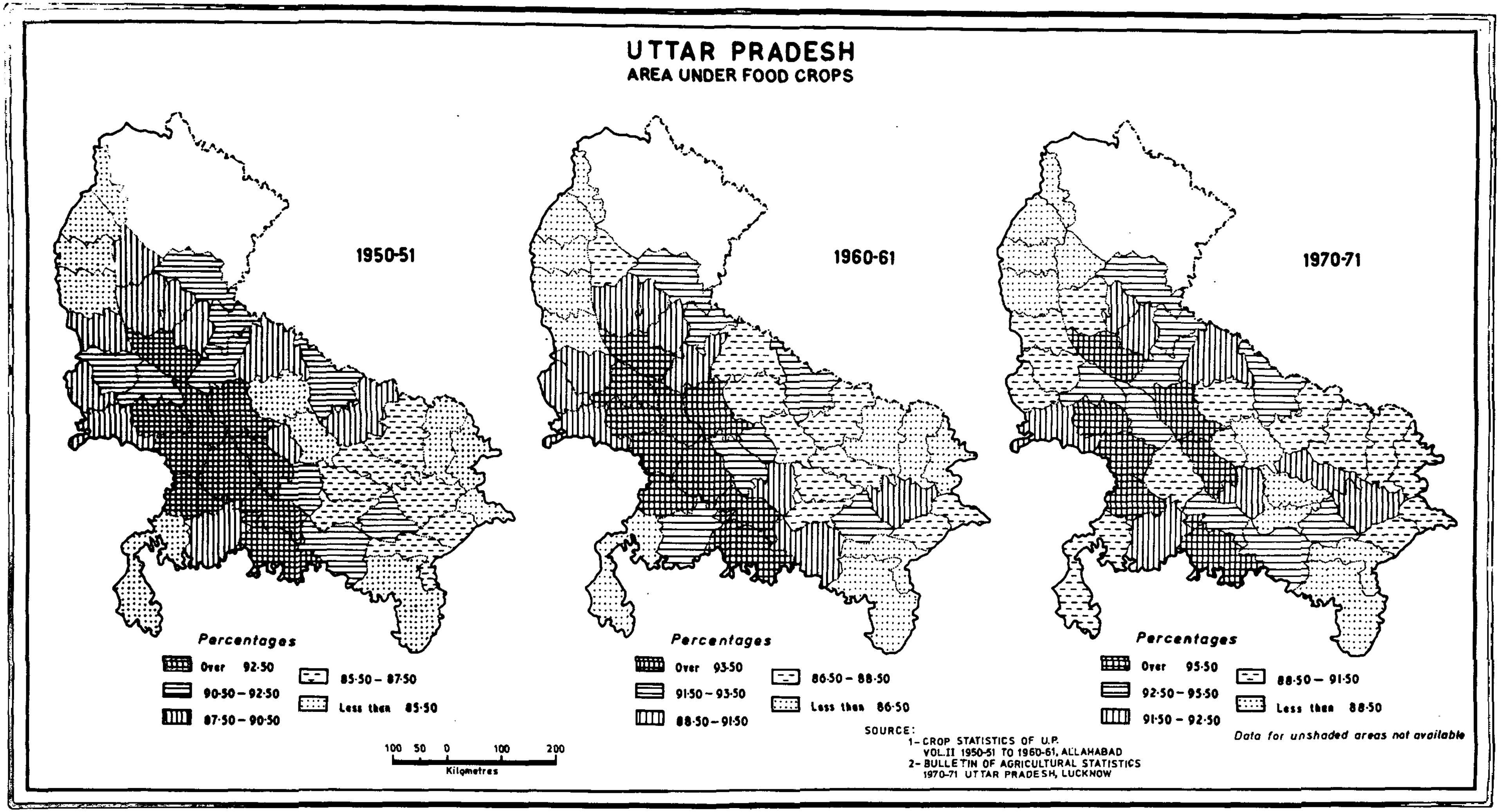
Name of Districts	1950-51 Area	1950-51 Percentage	1960-61 Area	1960-61 Percentage	1970-71 Area	1970-71 Percentage
1	2	3	4	5	6	7
Dehra Dun	50,106	75.49	47,339	66.45	62,653	76.42
Saharanpur	3,68,658	79.17	4,12,868	81.95	4,51,168	81.54
Muzaffar-nagar	3,13,873	77.08	3,29,485	77.66	3,76,023	78.66
Meerut	5,03,804	79.92	5,11,478	78.59	5,63,323	80.12
Bulandshahr	4,45,452	88.36	4,57,172	88.40	5,10,613	88.64
Aligarh	4,53,799	90.19	4,77,205	90.50	5,41,015	91.12
Mathura	3,14,275	87.73	3,35,735	89.56	3,65,311	89.72
Agra	3,49,664	89.25	3,81,430	90.79	4,07,464	92.05
Mainpuri	3,01,349	93.72	3,36,631	95.11	3,76,452	96.11
Etah	3,51,707	91.68	3,82,582	93.85	4,20,721	94.02
Bareilly	3,36,169	88.57	3,68,891	90.08	3,97,334	92.46
Bijnor	2,91,561	86.55	3,16,993	86.09	3,69,000	87.85
Budaun	4,41,271	94.27	4,54,976	95.65	4,94,978	96.04
Moradabad	4,72,674	88.32	4,96,992	90.06	5,76,394	91.07
Shahjahanpur	3,24,309	90.00	3,51,401	89.62	3,87,915	93.01
Pilibhit	1,79,368	90.88	2,35,489	92.64	2,62,456	93.38
Rampur	1,58,771	89.06	2,27,809	89.86	2,48,420	91.61
Farrukhabad	3,09,160	94.16	3,29,392	93.09	3,68,664	94.53
Etawah	2,87,717	92.94	3,35,976	93.87	3,73,221	95.53
Kanpur	4,52,787	99.45	4,90,431	93.91	4,74,060	90.00
Fatehpur	2,84,351	92.75	3,19,129	94.03	3,41,280	94.62
Allahabad	4,78,220	92.28	5,40,857	90.69	5,80,347	92.76
Jhansi	3,23,080	79.63	3,14,412	65.57	4,76,245	89.20
Jalaun	3,05,529	94.07	3,51,156	96.07	3,74,427	98.05
Hamirpur	3,72,635	88.67	4,58,141	93.07	4,82,581	92.40
Banda	4,03,055	94.66	5,27,620	96.05	5,68,902	96.87
Varanasi	3,57,685	86.62	3,68,833	82.74	3,95,207	84.87

(contd.....)

TABLE IX (Contd...)

1	2	3	4	5	6	7
Mirzapur	2,97,504	82.00	3,60,468	77.71	3,74,411	78.65
Jaunpur	3,44,423	90.18	3,39,037	91.54	3,63,901	93.49
Ghazipur	2,67,022	87.36	2,75,444	87.36	3,17,432	90.27
Ballia	2,55,048	84.49	2,60,628	86.41	2,77,083	90.16
Gorakhpur	4,98,526	83.89	5,31,419	83.76	5,85,762	89.20
Deoria	4,76,747	83.69	4,68,696	83.60	5,36,930	88.78
Basti	6,63,033	86.39	6,44,626	85.21	7,07,011	90.90
Azamgarh	4,54,233	87.25	4,79,611	88.52	5,21,317	91.90
Naini Tal	95,934	92.24	2,08,494	92.15	2,58,829	93.57
Lucknow	1,63,890	88.09	1,77,135	92.09	1,79,791	91.24
Unnao	2,97,685	93.99	3,40,462	93.14	3,82,225	96.04
Rae Bareli	2,94,665	90.01	3,37,633	90.44	3,55,200	92.06
Sitapur	3,96,939	75.39	4,76,410	87.44	4,81,594	89.72
Hardoi	4,25,975	94.63	4,60,126	95.13	5,08,468	96.76
Kheri	4,05,641	87.80	4,74,623	87.99	5,23,684	91.64
Faizabad	3,43,533	86.33	3,80,821	87.54	3,88,168	91.22
Gonda	5,92,170	88.67	6,53,696	88.15	6,61,046	91.33
Bahraich	5,14,428	90.76	5,61,835	91.43	5,76,099	94.68
Sultanpur	3,16,871	86.11	3,38,591	87.89	3,47,203	85.29
Pratapgarh	2,56,057	87.01	2,64,159	88.33	2,74,764	88.11
Bara Banki	3,43,537	84.25	3,67,469	86.65	3,65,321	85.41
Uttar Pradesh	1,76,29,000	91.53	1,89,22,000	90.00	2,05,02,000	92.46

for the State shows a growth rate between the periods 1950-51 and 1960-61 as only 0.70 per cent and between 1960-61 and 1970-71 as 0.80 per cent per annum. And from the districtwise details of growth rate, it is evident that there are five districts of Naini Tal, Rampur, Pilibhit, Banda and Hamirpur



UTTAR PRADESH
AREA UNDER FOOD CROPS
1950-51
1960-61
1970-71
Percentages
Over 92·50
90·50 – 92·50
87·50 – 90·50
85·50 – 87·50
Less than 85·50
Percentages
Over 93·50
91·50 – 93·50
88·50 – 91·50
86·50 – 88·50
Less than 86·50
Percentages
Over 95·50
92·50 – 95·50
91·50 – 92·50
88·50 – 91·50
Less than 88·50
100 50 0 100 200
Kilometres
SOURCE:
1- CROP STATISTICS OF U.P. VOL.II 1950-51 TO 1960-61, ALLAHABAD
2- BULLETIN OF AGRICULTURAL STATISTICS 1970-71 UTTAR PRADESH, LUCKNOW
Data for unshaded areas not available

FIG. 33

where the growth of food crops area ranged between 2 and 3 per cent, except one Naini Tal which recorded 8.07 per cent per annum between 1950-51 and 1960-61. There are five districts, viz., Dehra Dun, Jhansi, Jaunpur, Deoria and Basti which recorded negative growth ranging between -0.15 and -0.56 per cent per annum. Besides these, in the remaining districts of the State, the growth rates during the corresponding period were identified less than one per cent and 1-2 per cent per annum.

The figures of growth rate during 1960-61 and 1970-71 show almost no achievement in the area under food crops. Three districts of Jhansi, Dehra Dun and Naini Tal show the areal growth rate under food crops as 4.23, 2.84 and 2.18 per cent per annum respectively. Apart from these the growth rates computed for other districts of the State are either same as between 1950-51 and 1960-61 or of less significance. The two districts of Kanpur and Bara Banki exhibit the negative growth being -0.33 and -0.05 per cent respectively.

(d) Patterns of Crop-Combination

An attempt has been made to study the crop-association for determining the crop-combination regions in the districts of Uttar Pradesh. A number of statistical procedures have been worked out to delineate the crop-combination region.[12] In order to delineate the combinations, Doi's method has been adopted, as it is an improvement over Weaver's method. Doi, has introduced a slight modification to Weaver's formula by substituting $\frac{\Sigma d2}{n}$ with Σd^2 or the sum of squared differences. Thus the combination having the smallest Σd^2 will be the combination formed by the major crops only. Therefore, Σd^2 may be consulted from the table of critical values which the Doi, has himself provided.[13]

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12. This includes among many others: Weaver, J.C., "Crop-Combination Regions in the Middle West", Geographical Review, Vol.XLIV, 1954, pp.175-200. - Doi, K., "The Industrial Structure of Japanese Prefactures", Proceedings of the IGU Regional Conference in Japan, 1957 & 1959, pp.310-16.- Rafiullah, S.M., "A New Approach to the Functional Classification of Towns", The Geographer, Vol.XII, 1965, pp.40-53.- Siddique, M.F., "Combinational Analysis- A Review of Methodology, The Geographer, Vol.XIV, 1967, pp.81-99.- idem, Crop Combinations and Specialization in India, The Geographer, Vol.XXI, No.1, 1974, pp.76-88.- Ahmad, A., and Siddique, M.F., "Crop Association Patterns in the Lumi Basin", The Geographer, Vol.XIV, 1967, pp.69-80. Kostrowicki, J., "Some Methods and Techniques to Determine Crop and Other Land Use Combinations as Used in the Polish Land Use Studies", Proceedings of 21st IGC, Symposium on Land Use in Developing Countries, Aligarh, 1972, pp.83-97.
13. In brief, instead of squaring the differences, it is required to sum up the percentages and then consult the table for the critical value of the next element at that accummulated percentage level. If the critical value is higher than the actual percentage, the crop is not considered, but if otherwise the value is lower than the crop percentages, the crop is included in the combination.

To illustrate the statistical procedure involved, the case of district Bareilly may be cited. Individual crop percentages in Bareilly during 1970-71 or given below (alphabetical symbols used here are:

W = Wheat; R = Rice; S = Sugarcane; G = Gram; O= Oilseeds; M = Maize; J = Jowar; Pl = Pulses; B = Bajra; A = Arhar; By = Barley; and P = Potato)

W 30.73; R 24.48; S 9.85; G 8.21; O 6.64; M 4.56, J 4.48, Pl 4.00; B 3.96; A 2.00; By 0.55; and P 0.49.

Table X shows the critical values for only those sums of percentages which are required in the present case.

TABLE X

Doi's Combinational Analysis Table

Rank of elements	Sum of percentages of higher ranking elements			
	50	55	66	74
2	0.00	5.53	20.00	-
3	0.00	2.60	9.67	15.58
4	0.00	1.73	6.07	10.00
5	0.00	1.29	4.51	7.35
6	0.00	1.04	3.59	5.51

Source: Doi, K., op. cit.

In the first instance, all those crops are included in the combination whose accummulated percentage is less than 50, as the critical value for all the elements at 50 is 0. In Bareilly, first crop occupies 30.73 per cent so that the next crop is automatically included. It makes the sum of the two crops (30.73 + 24.48) 55.21 (or 55). Now under the heading 55, the heading 55, the critical value for the third element is 2.60. Since the third crop occupies 9.85 per cent area is larger than 2.60 it is included in the combination. The accummulated percentage of three elements (30.73 + 24.48 + 9.85) comes to 66.06 (or 66) where the critical value for 4th element is 6.07. As fourth crop occupies 8.21 per cent i.e., larger than 6.07, it is also included in the combination. It makes the total for 4 crops (30.73+24.48+9.85+8.21) 74.27 (or 74) per cent. The critical value at this percentage for fifth element is 7.35. Because the percentage occupied by fifth crop (6.64) is lesser than 7.35, it is excluded from the combination. Thus 4 crop-combination (WRSG) is alotted to Bareilly during 1970-71.

(e) Crop-Combination Regions

Crop-combination regions based on Doi's formula have been worked out for the three separate decennial years e.g., 1950-51, 1960-61 and 1970-71, and are shown in Fig.34. It will be seen from Fig.34 that during the year 1970-71 the

UTTAR PRADESH

CROP COMBINATION REGIONS

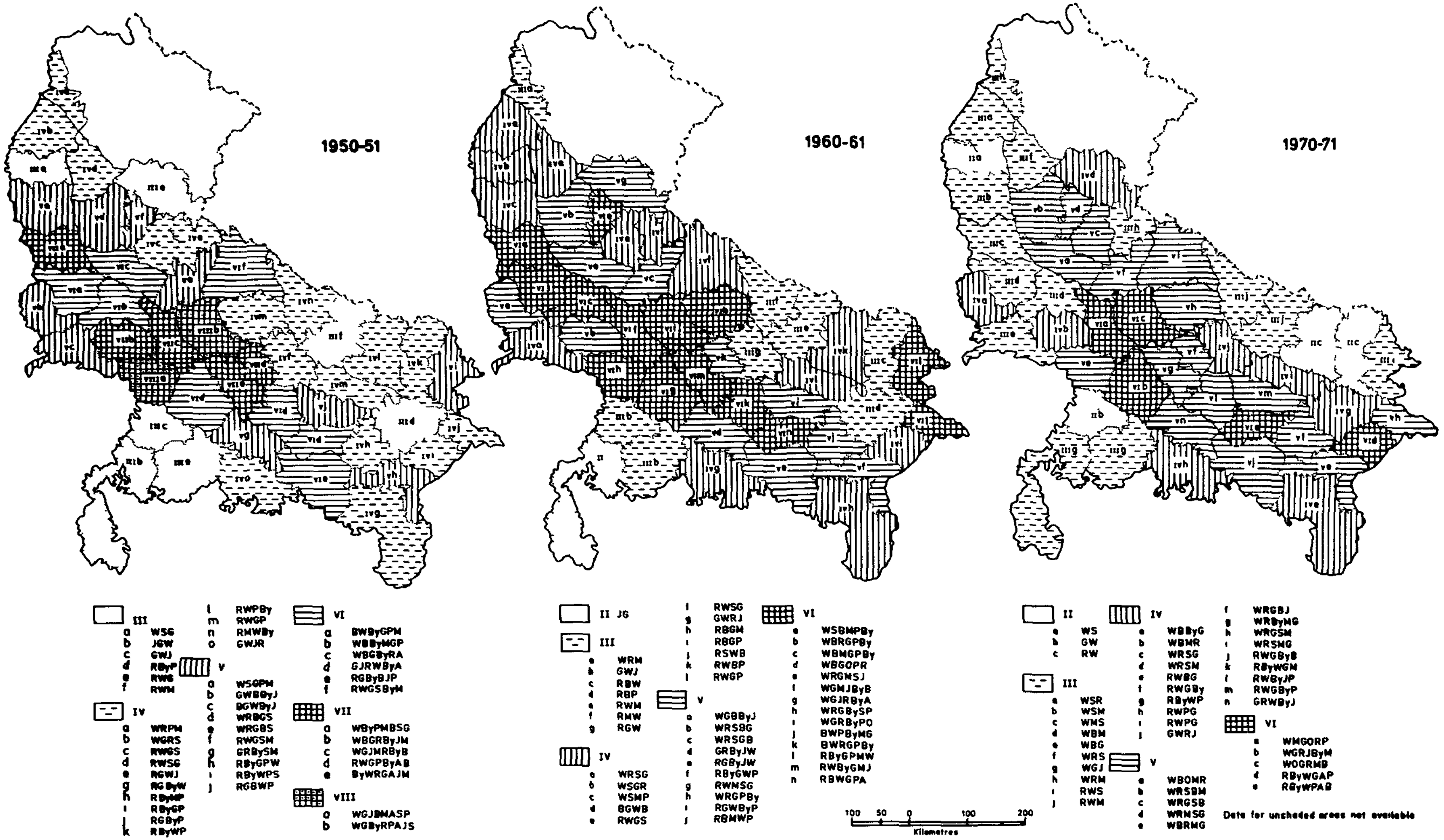


FIG. 34

combinations ranged in all the districts from 2 to 7 crops. The lowest combinations constituting 2 crops region were predominent in the four districts of Muzaffarnagar, Jalaun, Gorakhpur and Basti, wheat being the common crop. Three crop-combinations existed in fourteen districts of the State, where wheat and rice were the common crops in certain districts and in other areas rice was replaced by sugarcane and gram. The four and five crop - combinations were common in eleven and fourteen districts respectively. Out of the eleven districts of four crops combination, Mathura and Mainpuri districts followed wheat and bajra as a common crops, and in the districts of Varanasi, Jaunpur, Azamgarh and Mirzapur, wheat and barley were the common crops. Among the remaining five districts, viz., Bareilly, Banda, Naini Tal, Faizabad and Bara Banki; both Bareilly and Naini Tal have rice, wheat and sugarcane as a common crops, and the last three possessed rice, wheat and gram as common crops. In an another set of fourteen districts under five crop-combinations wheat, rice and gram alongwith barley crops are common components. Within this group of districts, in some cases this order of crop component is replaced by other crops. Out of four districts, Farrukhabad, Kanpur, Hardoi and Pratapgarh, in three districts, except Pratapgarh rice, wheat, barley and gram are common components in the six crop-combinations in the State. During the corresponding year, seven crop-combination emerges in Ghazipur, one of the easternmost districts and the crops follow the order of: rice, barley, wheat, gram, arhar, pulses and bajra.

(f) Temporal Changes in Crop-Combinations

The relative positions of crop-combination regions during last two decennial years are also worked out (Fig.34). The position of crop-combinations during 1950-51 was relatively more diversified with 3 to 8 combinations i.e., showing a very high degree of diversification. In Uttar Pradesh, 4 and 5 crop-combinations were concentrated over large areas and covering altogether twenty six districts.

During 1960-61 seven and eight combinations almost disappeared from the scene as were visible covering five and two districts respectively in 1950-51 and one district Ghazipur under seven crop-combinations in 1970-71. During this year (1960-61) fourteen districts were having four crop-combinations, and about equal number of this under six crop-combinations. And among the remaining districts, eight were categorised having three crop-combinations and ten districts under five crop-combinations.

(g) Districtwise Variations in Food Crops Production

Food crops gross production recorded in each district during the corresponding decennial years is shown in Table XI. Fig.35 is based on data produced in Table XI and their details (districtwise/cropwise) are produced in Appendices VI to VIII. The districts represented different ranges of production during 1970-71 are namely, Saharanpur, Muzaffarnagar, Meerut and Bulandshahr of upper Doab, and two Bijnor and Moradabad of Rohilkhand region where the figures exceed more than 2 million tonnes and alongwith these may be included the districts of Naini Tal, Bareilly, Pilibhit, Shahjahanpur, Kheri, Gorakhpur, Deoria and Basti where the production recorded between the range of 1.5 and 2.0 million tonnes and in two districts Kheri and Deoria over 2 million tonnes. It is evident that all of them belong to State's sugarcane growing belt. Next to these, nine districts of Aligarh, Mathura, Budaun, Rampur, Varanasi, Jaunpur, Hardoi, Faizabad and Bara Banki recorded gross production between the range of 1 and 1.5 million tonnes. In between the range 0.5 and 1.0 million tonnes of production fall the districts of lower and middle Doab, the three adjoining districts of eastern part, viz., Azamgarh, Ballia and Ghazipur. Among the four districts south of Yamuna belonging to Bundelkhand region and also in the district of Mirzapur lying on the southeastern corner of the State, the production of food crops ranged below 0.5 million tonnes.

Temporal comparisons regarding to crop production can also be assessed from Fig.35. The spatial patterns in crop productions seems to be stationery, but each pocket of districts belonging to certain range of production shows the increasing trend in total volume of production. This position is rather significant between the decennial years 1950-51 and 1960-61 in which the overall increase in production figures is one and a half time more in 1960-61 compared to 1950-51.

(h) Rate of Growth in Food Crops Production

Rate of growth computed for the gross production in each of the districts shows an upward trend from 1950-51 to 1960-61 i.e., since the begining of First Five Year Plan. The highest growth is achieved in two districts Naini Tal 21.14 per cent and Gonda 12.82 per cent per annum. In other areas, particularly in the eight districts of Gorakhpur, Dehra Dun, Basti, Mathura, Ghazipur, Aligarh, Deoria and Azamgarh the rate of increase was between 7.5 and 10.0 per cent per year. Among the other groups consisting of fourteen districts, the growth amounted between 5.5 and 7.0 per cent per annum. In eight districts, viz., Mirzapur, Meerut, Bareilly, Banda, Fatehpur, Bara Banki, Varanasi, Shahjahanpur and Sultanpur the increase was from 4-5 per cent per annum. Among the remaining sixteen districts the rate of growth lies below 4 per cent.

During the period between 1960-61 and 1970-71 the rate of increase is less compared to the previous decennial years. The highest growth is indicated in four districts,

TABLE XI

Districtwise food crops production levels in U.P.

(in metric tonnes)

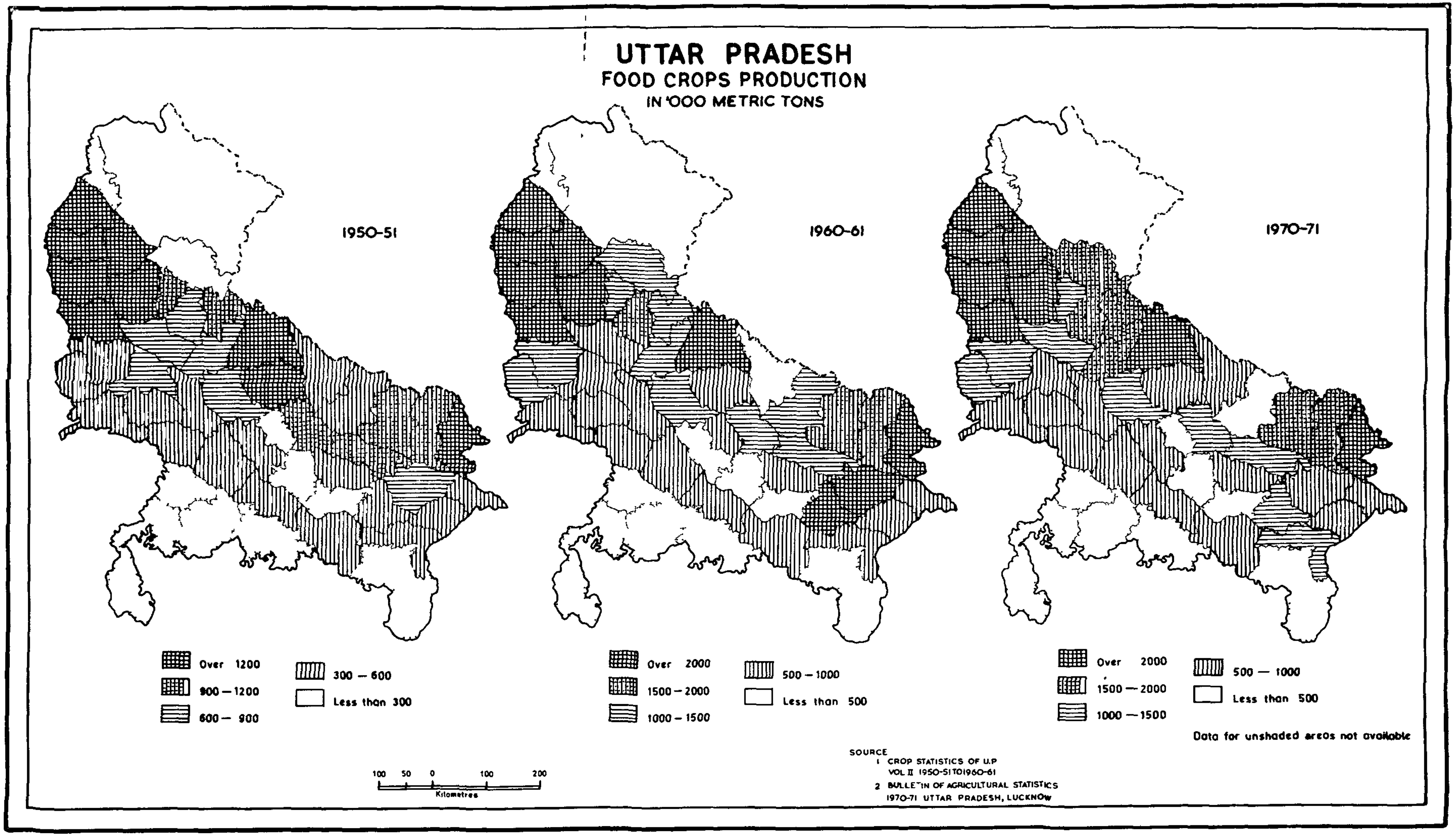
Name of district	1950-51	1960-61	1970-71
1	2	3	4
Dehra Dun	97,714	2,34,573	2,88,241
Saharanpur	18,93,321	35,66,401	41,04,510
Muzaffarnagar	26,83,063	51,84,977	62,28,712
Meerut	41,76,523	67,52,879	71,81,565
Bulandshahr	17,47,087	33,80,073	26,28,492
Aligarh	5,95,878	13,27,077	12,76,745
Mathura	5,37,057	12,06,799	10,72,608
Agra	4,12,835	7,33,891	5,55,440
Mainpuri	4,19,148	5,70,013	6,07,923
Etah	6,02,794	6,60,719	9,07,256
Bareilly	11,27,423	18,12,483	18,79,785
Bijnor	17,17,704	29,97,843	39,72,266
Budaun	10,34,056	7,91,107	13,65,038
Moradabad	19,42,783	33,44,776	34,00,223
Shahjahanpur	9,84,392	14,59,201	17,13,022
Pilibhit	6,80,143	12,74,171	16,63,860
Rampur	6,61,181	11,56,685	11,90,507
Farrukhabad	5,78,124	7,01,877	9,09,400
Etawah	4,93,316	6,71,319	6,76,438
Kanpur	5,46,921	7,85,954	8,45,950
Fatehpur	3,61,835	5,71,263	6,21,924
Allahabad	4,42,362	7,77,794	7,48,690
Jhansi	2,20,676	3,89,159	4,20,786
Jalaun	2,31,054	2,94,699	3,29,691
Hamirpur	2,96,276	4,29,930	4,46,441
Banda	2,82,233	4,50,647	4,69,412
Varanasi	6,04,386	9,18,600	10,52,267
Mirzapur	2,98,935	4,86,541	4,99,503

(contd...)

TABLE XI (Contd...)

1	2	3	4
Jaunpur	8,06,953	11,49,907	11,80,800
Ghazipur	3,28,526	7,35,988	8,91,205
Ballia	5,31,991	9,21,459	9,19,860
Gorakhpur	6,46,630	16,07,085	18,25,371
Deoria	17,33,067	37,23,831	36,63,147
Basti	8,27,361	19,43,013	18,61,204
Azamgarh	10,05,250	20,41,911	18,54,894
Naini Tal	2,00,651	13,66,649	19,74,915
Lucknow	2,10,660	2,39,227	2,95,429
Unnao	5,49,848	5,70,519	6,00,291
Rae Bareli	2,98,738	4,21,904	4,31,574
Sitapur	12,95,577	16,33,257	19,18,151
Hardoi	9,73,836	10,83,664	14,59,573
Kheri	13,93,935	25,67,984	34,19,412
Faizabad	7,83,551	13,35,953	13,66,461
Gonda	3,63,666	12,15,486	4,59,839
Bahraich	3,02,519	4,36,771	6,68,488
Sultanpur	4,93,598	7,18,597	7,32,347
Pratapgarh	2,90,938	3,70,147	4,70,341
Bara Banki	6,70,097	10,51,940	11,34,355
Uttar Pradesh	3,27,24,000	6,97,17,000	7,14,77,000

viz., Bahraich, Naini Tal, Hardoi and Etah where they experienced increase between the range of 3.5 and 4.5 per cent per annum. Among the other seven districts namely, Kheri, Bijnor, Pilibhit, Farrukhabad, Pratapgarh, Basti and Dehra Dun the increase was recorded between 2 and 3 per cent per annum.



UTTAR PRADESH
FOOD CROPS PRODUCTION
IN '000 METRIC TONS
1950-51
1960-61
1970-71
Over 1200
900 — 1200
600 — 900
300 — 600
Less than 300
Over 2000
1500 — 2000
1000 — 1500
500 — 1000
Less than 500
Over 2000
1500 — 2000
1000 — 1500
500 — 1000
Less than 500
Data for unshaded areas not available
100 50 0 100 200
Kilometres
SOURCE
1 CROP STATISTICS OF U.P VOL II 1950-51 TO 1960-61
2 BULLETIN OF AGRICULTURAL STATISTICS 1970-71 UTTAR PRADESH, LUCKNOW

FIG.35

Among the remaining districts, seven show negative increase ranging between -0.01 per cent and -0.95 per cent, and the others show increase less than 2 per cent per annum.

CHAPTER VII

FOOD CROPS PRODUCTIVITY REGIONS IN UTTAR PRADESH

Since the begining of First Five Year Plan i.e., 1950-51 considerable efforts are being implemented in order to improve the agricultural output. A variety of agricultural inputs and incentives have been provided to the farmers at the macro as well as micro level to promote the productivity of agriculture.

In this study an attempt has been made to study agricultural productivity in the districts of Uttar Pradesh from three angles:

(i) To determine inter-district variations in food crops productivity at a given point of time,

(ii) to assess the changes in productivity between three points of time, and

(iii) to assess the growth of productivity during the study periods.

Productivity indices have been determined as explained e.g., for three points of time 1950-51, 1960-61, and 1970-71 in fortyeight districts of the State (Plain portions). The crops considered are, viz., rice, jowar, bajra, maize, wheat, barley, gram, arhar, pulses (including urd, moong, moth and masur), oilseeds (including groundnut, mustard, linseed, castor and rapeseed), sugarcane and potato. Figures pertaining to area and production were obtained from official sources.[1]

Choice of Productivity Measure

In order to assess variations in crop productivity in different agro-economic regions of the State, among the others, four productivity evaluating methods have adopted to apply in order to compute productivity indices in each of the selected districts for the above mentioned periods, as well as crops considered.

First method describes, the computation of productivity on the basis of 'Crop Yield Index'.[2] The second, deals with the population supporting capacity i.e., available 'Standard Nutrition Unit' for human consumption per hectare as proposed by Stamp.[3] The third and fourth methods describe price-weighted productivity variations i.e., output per hectare, and output per active agricultural worker in monetary terms.

Computation of Productivity Increase

The average annual per cent rates of productivity increase have been calculated for the four productivity indices

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1. Crop Statistics of Uttar Pradesh 1950-51 to 1960-61, Vol.II; and Bulletin of Agricultural Statistics 1970-71, (Annual), Directorate of Agriculture, Uttar Pradesh, Lucknow.
2. F.A.O., Methods of Farm Management Investigations, op. cit., p.62. - Tambad, S.B., "Spatial and Temporal Variations in Agricultural Productivity in Mysore State", op. cit., pp.39-45.- Tambad, S.B., and Patel, K.V., "Crop Yield Index as a Measure of Productivity", op. cit., pp.979-80.
3. Stamp, L.D., "The Measurement of Land Resources", op. cit., pp.110-16.

for the study periods by using the following formula.

Exponential growth formula for computing rate of productivity change. The formula would be read thus:

$$R = \left(\sqrt[t]{\frac{P_1}{P_2}} - 1\right) \times 100$$

where

R = rate of increase per cent per annum,

P_1 = the productivity index in 1960-61,

P_2 = the productivity index in 1950-51,

t = the period of 10 years between 1950-51 and 1960-61.

A. Regional Differences in Food Crops Productivity-Based on Crop Yield Index

Yang's crop yield index method deals with the calculating index on the average yield basis of different crops selected for enumeration on a unit area and the yields of those crops in the entire study area. The method describes to divide the average yield of the crop per hectare on a particular farm by the average yield of the crop in the entire region. A percentage figure thus obtained by multiplying with 100 gives the index number as shown in 5th column of Table XI. The product is obtained by taking the area under selected crops as weight and multiplying it with the index number. The final crop yield index is thus obtained by adding the products of different crops and dividing it by the total area under all the crops selected.

TABLE XI

Methods of calculating Crop Yield Index of X farm

Name of crop	Yield in Qnts. per hectare		Area under crop on Farm X	Crop yield on Farm X as a percentage of the region (col.3/col. 2 x 100)	Percentage multiplied by area under crop (col.3 x col.4)
	Average in the entire region	Farm X			
1	2	3	4	5	6
Wheat	20	22	10	110	1,100
Rice	18	17	10	94	940
Barley	22	20	5	91	455
Maize	30	36	15	120	1,800
Total	-	-	40	-	4,295

Thus, crop index on farm X = 4,295/40 = 107 per cent.

Table XII, and Figs.36 and 37 show the districtwise yield indices computed for the decennial years 1950-51, 1960-61 and 1970-71. Fig.36 shows a number of districts categorised under a specific range of yield indices and Fig.37 exhibits a comparative position of each district graphically in respect of their yield index value for the above three points of time.

On the basis of above method the variations in productivity spatially are largely concentrated and partially scattered in different natural as well as economic regions of the State. Yield indices computed for the year 1970-71 indicate the areas of high productivity which comparise the Ganga-Yamuna Doab, mainly the districts of Bulandshahr, Aligarh, Mathura and Etah of middle Doab, two districts namely, Etawah and Kanpur of the middle and the lower Doab. These districts show very high indices as above 120 per cent. Two districts namely, Muzaffarnagar and Meerut of upper Doab show the indices as 116.17 and 114.91 per cent respectively. Saharanpur of upper, Mainpuri of middle and Fatehpur from lower Doab fall under the medium productivity group i.e., between the range of 100 and 110 per cent. Apart from these, two districts namely, Naini Tal and Rampur show productivity between 110 and 120 per cent. Five districts, viz., Budaun, Bara Banki, Rae Bareli, Jaunpur and Gorakhpur representing different regions fall between the productivity range of 100 and 110 per cent i.e., of medium category. Among the remaining districts more than half of them fall between the range of 90 and 100 per cent, and less than half show productivity indices below 90 per cent. The districts possessing the indices less than 90 per cent belong to mainly Trans-Ghaghara and Bundelkhand tracts of the State, they are agriculturally less developed and the outturn per hectare is low as compared to other regions of the State.

TABLE XII

Districtwise Crop Yield Indices in U.P.

(Figures in Percentage)

Name of district	1950-51	1960-61	1970-71
1	2	3	4
Dehra Dun	132.61	130.54	98.38
Saharanpur	102.62	103.56	101.04
Muzaffarnagar	118.36	119.32	116.17
Meerut	104.37	115.00	114.91
Bulandshahr	90.35	102.87	130.20
Aligarh	72.09	85.56	133.87
Mathura	72.54	105.43	120.99
Agra	99.67	122.86	90.08
Mainpuri	112.15	99.86	105.60
Etah	82.78	104.52	124.92
Bareilly	78.21	94.17	97.02
Bijnore	98.44	101.34	94.60
Budaun	93.41	93.16	105.39
Moradabad	93.04	92.36	99.94
Shahjahanpur	91.58	98.44	97.67
Pilibhit	99.79	85.40	91.99
Rampur	98.15	102.02	114.78
Farrukhabad	100.77	110.06	112.54
Etawah	119.40	115.14	127.86
Kanpur	122.44	124.39	125.94
Fatehpur	103.54	118.24	107.68
Allahabad	94.28	110.88	93.60
Jhansi	91.83	99.21	82.00
Jalaun	89.63	106.14	72.34
Hamirpur	101.71	103.04	86.30
Banda	98.98	110.60	84.28
Varanasi	90.29	109.37	91.62
Mirzapur	76.54	111.34	90.48
Jaunpur	105.49	99.95	104.52

(contd...)

TABLE XII (Contd...)

1	2	3	4
Ghazipur	88.27	106.34	94.29
Ballia	99.91	99.25	92.43
Gorakhpur	82.72	85.12	104.11
Deoria	91.87	84.07	89.28
Basti	78.31	78.76	88.43
Azamgarh	107.76	92.94	91.94
Naini Tal	96.29	118.65	124.79
Lucknow	109.70	109.90	98.44
Unnao	112.48	101.45	82.96
Rae Bareli	114.99	115.69	101.45
Sitapur	106.03	90.05	88.23
Hardoi	107.30	89.85	107.24
Kheri	90.92	84.53	71.62
Faizabad	105.90	100.23	77.48
Gonda	78.89	76.47	76.93
Bahraich	79.52	73.38	77.59
Sultanpur	105.24	100.73	95.23
Pratapgarh	97.02	90.59	99.36
Bara Banki	93.28	110.56	98.93

(a) Temporal Comparisons in Productivity Indices

Yield indices measuring productivity for selected food crops have been computed for 1950-51, 1960-61 and 1970-71 to assess the changes that have occurred within a span of two decades in each of fortyeight district of the State. Temporal comparisons can also be made from Table XII, and

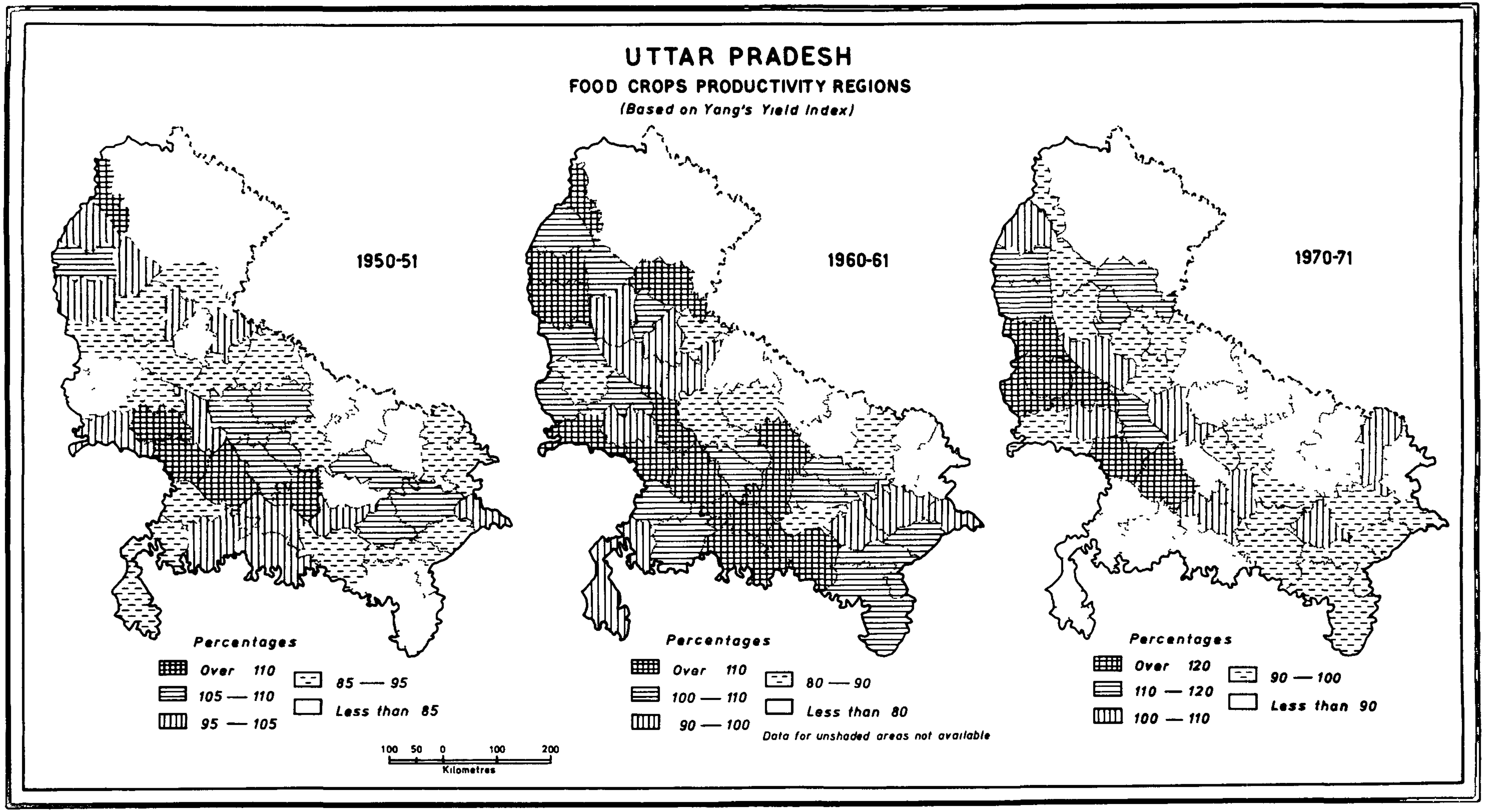
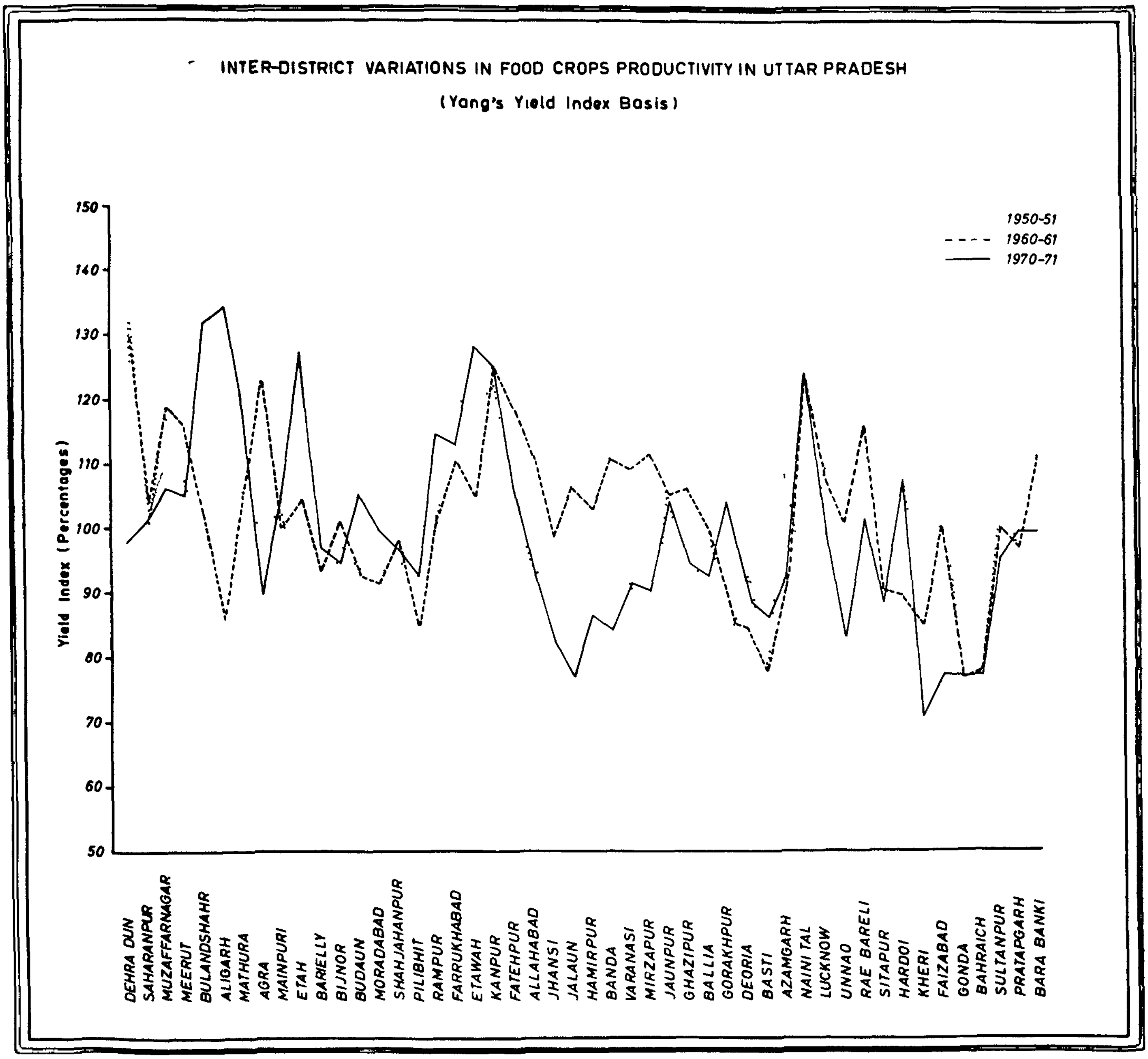

UTTAR PRADESH
FOOD CROPS PRODUCTIVITY REGIONS
(Based on Yang's Yield Index)
1950-51
Percentages
Over 110
105 — 110
95 — 105
85 — 95
Less than 85
100 50 0 100 200
Kilometres
1960-61
Percentages
Over 110
100 — 110
90 — 100
80 — 90
Less than 80
Data for unshaded areas not available
1970-71
Percentages
Over 120
110 — 120
100 — 110
90 — 100
Less than 90

FIG. 36



INTER-DISTRICT VARIATIONS IN FOOD CROPS PRODUCTIVITY IN UTTAR PRADESH
(Yang's Yield Index Basis)
1950-51
1960-61
1970-71
Yield Index (Percentages)
150
140
130
120
110
100
90
80
70
60
50
DEHRA DUN
SAHARANPUR
MUZAFFARNAGAR
MEERUT
BULANDSHAHR
ALIGARH
MATHURA
AGRA
MAINPURI
ETAH
BARIELLY
BIJNOR
BUDAUN
MORADABAD
SHAHJAHANPUR
PILIBHIT
RAMPUR
FARRUKHABAD
ETAWAH
KANPUR
FATEHPUR
ALLAHABAD
JHANSI
JALAUN
HAMIRPUR
BANDA
VARANASI
MIRZAPUR
JAUNPUR
GHAZIPUR
BALLIA
GORAKHPUR
DEORIA
BASTI
AZAMGARH
NAINI TAL
LUCKNOW
UNNAO
RAE BARELI
SITAPUR
HARDOI
KHERI
FAIZABAD
GONDA
BAHRAICH
SULTANPUR
PRATAPGARH
BARA BANKI

FIG. 37

Figs.36 and 37 show the changes that have taken place in due course in each district. Productivity indices based on crop yield index in the districts of Meerut, Bulandshahr, Mathura, Agra, Etah, Farrukhabad and Allahabad of the Doab region exhibit a sharp increase in index value from 1950-51 to 1960-61. Meerut shows the index of 104.37 to 115.00 per cent, Bulandshahr 90.35 to 102.87 per cent, Mathura 72.09 to 85.56 per cent, Agra 99.67 to 122.86 per cent, Etah 82.78 to 104.52 per cent, Farrukhabad 100.77 to 110.06 per cent and Allahabad 94.08 to 110.88 per cent. The other districts representing the remaining parts of the State are Naini Tal of sub-Montane tract, Jalaun and Banda forming the parts of Bundelkhand region, Bara Banki of central region, and Varanasi and Mirzapur from southeastern part. In them the increase recorded for Naini Tal 90.29 to 118.65 per cent, Jalaun 89.63 to 106.14 per cent, Banda 98.98 to 110.60 per cent, Bara Banki 93.28 to 110.56 per cent, and Varanasi and Mirzapur 90.29 to 109.37 and 76.54 to 111.34 per cent respectively. Besides these, a few districts show increases in gradual order for instance, Saharanpur 102.62 to 103.56 per cent, Shahjahanpur 91.58 to 98.44 per cent, Kanpur 122.44 to 124.39 per cent, Jhansi 91.83 to 99.21 per cent, Hamirpur 101.71 to 103.04 per cent, Gorakhpur 82.72 to 85.12 per cent. Some districts have recorded a decrease in productivity during the corresponding decennial year namely, Dehra Dun, Mainpuri, Moradabad, Jaunpur, Deoria, Azamgarh, Sitapur, Hardoi, Kheri, Faizabad, Gonda, Bahraich, Sultanpur and Pratapgarh. The yield indices reduced in 1960-61 as compared to 1950-51 as in Dehra Dun 130.54 from 132.61 per cent, Mainpuri 99.86 from 112.15 per cent, Jaunpur 99.95 from 105.49 per cent, Deoria 84.07 from 91.87 per cent, Azamgarh 92.94 from 107.76 per cent, Sitapur 90.35 from 106.03 per cent, Hardoi 89.85 from 107.50 per cent, Kheri 84.53 from 90.92 per cent, Faizabad 100.23 from 105.90 per cent, Gonda 76.47 from 78.89 per cent, Bahraich 73.38 from 79.52 per cent, Sultanpur 100.73 from 105.24 and Pratapgarh 90.59 from 97.02 per cent.

During the next decennial year i.e., 1970-71 the yield indices show an increasing order in the districts of Bulandshahr in between 1960-61 and 1970-71 as 102.87 and 130.20 per cent, Aligarh 85.56 to 133.87 per cent, Mathura 105.93 to 120.99 per cent, Mainpuri 99.86 to 105.60 per cent, Etah 104.52 to 124.92 per cent, Budaun 93.16 to 105.39 per cent, Moradabad 92.36 to 99.94 per cent, Pilibhit 85.40 to 92.00 per cent, Rampur 102.02 to 114.78 per cent, Etawah 115.14 to 127.86 per cent, Jaunpur about 100 to 104.52 per cent, Gorakhpur 85.12 to 104.11 per cent, Naini Tal 118.65 to 124.79 per cent, Bahraich 73.38 to 77.59 per cent and Pratapgarh 90.59 to 99.36 per cent.

Among the remaining districts, some of them show a gradual increase for instance, as Bareilly 94.17 to 97.02

per cent, Farrukhabad 110.06 to 112.54 per cent, Kanpur 124.39 to 125.94 and Deoria 84.07 to 89.28 per cent, and some recorded a decrease between the two decennial years 1960-61 and 1970-71. There are three districts in upper Doab namely, Saharanpur, Muzaffarnagar and Meerut which exhibited a gradual decrease and one district Dehra Dun from sub-Montane tract recorded a decrease. Agra and Allahabad are other districts of Doab region where productivity indices have reduced during the year 1970-71. The entire Bundelkhand region shows a decrease in productivity during the corresponding year. Among the districts comprising central region of the State, viz., Lucknow, Unnao and Rae Bareli, Faizabad and Bara Banki also recorded indices in decreasing order.

(b) Growth Rate in Yield Indices

Increases in yield indices during the corresponding years have been computed from the exponential growth formula for each district of the State. Growth rates computed from the yield indices for the periods between 1950-51 and 1960-61, and 1960-61 and 1970-71 are listed in Appendix IV. Most of the districts representing different natural as well as agro-economic regions show an increase to a considerable extent, but there are a sizeable number of districts too which follow negative trend of growth.

The dimensions of growth in indices between the range 2 and 4 per cent per annum during 1950-51 and 1960-61 recorded in five districts, viz., Mathura, Agra, Etah (belonging to Doab region), Mirzapur and Naini Tal. The other twelve districts follow the trend of growth between 1 and 2 per cent per annum. Another group possessing positive growth less than one per cent may also be reckoned from the Appendix IV. Besides these, seventeen districts show a negative growth and out of them eleven have figures below -1.0 per cent and the remaining six, viz., Unnao, Mainpuri, Azamgarh, Pilibhit, Sitapur and Dehra Dun follow the negative growth between the range -1.0 and -2.0 per cent.

Subsequently, during the period of decennial years 1960-61 to 1970-71 three districts of Aligarh, Bulandshahr and Gorakhpur show the figures of indices growth as 4.57, 2.38 and 2.03 per cent per annum respectively. Among the other districts, nine follow growth between the range of 1 and 2 per cent, and the remaining eleven districts can be listed within the range less than one per cent per annum. During this period there is an equal number of districts which have recorded negative growth. Out of the twentyfour, ten districts have a growth rate of -1.0 per cent, and in the remaining districts it is more than -1.0 per cent per annum (Appendix X).

B. Regional Differences in Food Crops Productivity - Based on Standard Nutrition Unit.

Prof. Stamp has suggested 'Standard Nutrition Unit' as the basis for determining agricultural efficiency.[4] The main objective of this method is to convert food production per hectare into calories. The idea is borrowed from a table published by British Medical Association.[5] The table shows a range of desirable caloric intake among adults from 2,100 a day for a woman in sedentary occupation to 4,250 for a man engaged in active manual work. For children, the desirable intake is calculated as 800 a day for infants under one year to 3,400 for teenage boys. Taking into consideration the age structure of the population and the range of occupation; the weight and height of the people living under climatic conditions of northwestern Europe the average is 2,460 calories a day or about 9,00,000 calories per year. Stamp, called it as a 'Standard Nutrition Unit'.

Prof. Shafi has computed farm production into SNU under Indian conditions in the twelve villages of Eastern Uttar Pradesh, with an actual intake of 2,000 calories a day as minimum requirement (equivalent to 8,00,000 calories per

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4. Stamp, L.D., "The Measurement of Land Resources", op. cit., pp.110-16.
5. Ministry of Agriculture, Fisheries and Food, Manual of Nutrition, London, 1955.

year, taking into account a loss of 10 per cent in the general range of extraction rates i.e., the known losses in food production). The net caloric intake ranges in the villages from 1,828 a day (6,67,677 a year) to 2,175 a day (7,95,514 a year).[6] He assumed that, 8,00,000 calories be taken as Standard Nutrition Unit under Indian conditions.

Shafi, applied it to measure efficiency of food production in relation to population in India.[7] He considered the district as an area unit and acre/hectare yields of all the crops. Yield of crops were converted into calories and the figures thus obtained were divided by the number of crops considered to get the average value i.e., available SNU per hectare.

Following the same approach, an attempt has been made to compute SNU per hectare while incorporating the respective caloric values of each crop (Table XIII) for each of fortyeight districts for the three corresponding years. The total as well as per hectare SNU figures available in each district are arranged in Table XIV, and Fig.38 shows

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6. Shafi, M., Land Utilization in Eastern Uttar Pradesh (Aligarh, 1960), p.222.
7. Shafi, M., Food Production Efficiency and Nutrition in India", The Geographer, Vol.XIV, 1967, pp.23-27.
   idem, "Can India Support Five Times Her Population", Science Today, Vol.3, No.9, 1969, pp.21-27.

TABLE XIII

Caloric content in different food crops

Name of crop	Caloric value per 100 gm.
Rice	325
Jowar	349
Bajra	361
Maize	342
Wheat	345
Barley	336
Gram	334
Peas	398
Pulses	331
Oilseeds	567
Sugarcane	53
Potato	97

Source: Aykroyd, W.R., <u>The Nutritive Value of Indian Foods and Planning of Satisfactory Diets</u>, ICMR, New Delhi, 1966.

(i.e., less than 1 SNU per hectare) fall the whole of the Bundelkhand region, the middle and lower Doab regions comprising the districts of Etah, Mainpuri, Agra, Etawah, Farrukhabad, Kanpur, Fatehpur and Allahabad, five districts, viz., Unnao, Lucknow, Rae Bareli, Sultanpur and Bara Banki from the central part, two districts of Gonda and Bahraich from Trans-Ghaghara, and Mirzapur from southeastern part of the State.

a ranges of production of SNU per hectare in different parts of the State during the same study period.

Standard Nutrition Unit computed per hectare for the year 1970-71 for each district places the districts of Muzaffarnagar, Meerut and Saharanpur of the upper Doab at the highest rank; producing more than 4 SNUs per hectare. Among them, district Muzaffarnagar shows the figure of available SNU as 8.16 per hectare. The districts of Bijnor and Pilibhit from Rohilkhand, Naini Tal from sub-Montane tract, and Kheri and Deoria representing Tarai belt posses productivity of second order i.e., availability of SNU between 3 and 4 per hectare. Between the production range 2 and 3 SNU per hectare are the four districts of Moradabad, Rampur, Bareilly and Shahjahanpur from Rohilkhand region, Bulandshahr and Ballia from Doab and eastern regions respectively. The tracts possessing the productivity of low and very low order (between 1 and 2, and less than 1 SNU per hectare) are more diversified and occupy the larger parts of the State. The districts producing 1-2 SNU per hectare are Mathura and Aligarh from Doab, Budaun from Rohilkhand, Hardoi, Sitapur and Bara Banki from central part, Basti and Gorakhpur from Trans-Ghaghara tract, Faizabad, Azamgarh, Jaunpur, Varanasi and Ghazipur in the eastern region. Besides these, the remaining districts of the State possessed the available SNU figures less than 1 per hectare. Within this group

TABLE XIV

Districtwise production of Standard Nutrition Unit in U.P.

Name of district	1950-51 Total S.N.U	1950-51 S.N.U per ha.	1950-61 Total S.N.U	1950-61 S.N.U per ha.	1970-71 Total S.N.U	1970-71 S.N.U per ha.
1	2	3	4	5	6	7
Dehra Dun	44,894	0.89	1,12,992	2.38	1,37,469	2.19
Saharanpur	9,25,145	2.50	17,53,044	4.24	20,12,725	4.46
Muzaffarnagar	13,19,860	1.01	25,61,114	7.77	30,70,901	8.16
Meerut	20,53,491	4.07	33,23,040	6.49	35,11,903	6.23
Bulandshahr	8,47,296	1.90	16,51,484	3.61	10,90,728	2.13
Aligarh	2,69,885	0.59	6,29,549	1.31	5,72,443	1.05
Mathura	2,54,180	0.80	5,80,788	1.72	5,00,156	1.36
Agra	1,85,483	0.53	3,34,708	0.87	2,51,927	0.61
Mainpuri	1,85,719	0.61	2,54,931	0.75	2,55,849	0.67
Etah	2,75,598	0.78	3,01,681	0.78	4,07,113	0.96
Bareilly	5,47,006	1.62	8,81,036	2.38	9,08,951	2.28
Bijnor	8,38,981	2.87	14,75,654	4.65	19,55,247	5.29
Budaun	4,93,977	1.11	3,69,381	0.81	6,39,359	1.29
Moradabad	9,46,732	2.00	16,41,038	3.30	16,45,906	2.85
Shahjahanpur	4,69,774	1.44	6,99,463	1.99	8,20,211	2.11
Pilibhit	3,29,143	1.83	6,20,953	2.63	8,09,814	3.08
Rampur	3,21,540	2.02	5,61,299	2.46	5,68,482	2.28
Farrukhabad	2,47,727	0.80	2,97,656	0.90	3,50,734	0.95
Etawah	2,25,046	0.78	3,05,076	0.90	2,96,739	0.79
Kanpur	2,39,421	0.52	3,46,926	0.70	3,62,719	0.76
Fatehpur	1,61,185	0.56	2,57,767	0.80	2,78,561	0.81
Allahabad	1,88,438	0.39	3,44,111	0.63	3,09,475	0.53
Jhansi	94,532	0.29	1,68,017	0.53	1,80,257	0.37
Jalaun	1,00,944	0.33	1,31,839	0.37	1,43,796	0.38
Hamirpur	1,28,670	0.34	1,87,996	0.41	1,95,420	0.40
Banda	1,21,005	0.30	1,90,288	0.36	2,00,163	0.35
Varanasi	2,78,311	0.77	4,23,512	1.14	4,81,932	1.21

(contd....)

TABLE XIV (Contd...)

1	2	3	4	5	6	7
Mirzapur	1,36,610	0.45	2,18,259	0.60	2,19,347	0.58
Jaunpur	3,73,151	1.08	5,36,192	1.58	5,35,495	1.47
Ghazipur	1,48,970	0.55	3,43,364	1.24	4,14,280	1.30
Ballia	2,49,495	0.97	4,36,836	1.67	4,30,160	1.55
Gorakhpur	2,98,147	0.59	7,65,443	1.44	8,51,004	1.45
Deoria	8,39,617	1.76	18,25,510	3.89	17,82,301	3.31
Basti	3,79,515	0.57	9,24,299	1.43	8,62,535	1.21
Azamgarh	4,71,316	1.03	9,81,376	2.04	8,71,335	1.67
Naini Tal	96,153	1.00	6,68,495	3.20	9,63,519	3.72
Lucknow	92,485	0.56	1,06,477	0.60	1,24,281	0.69
Unnao	2,54,543	0.85	2,59,826	0.76	2,67,821	0.70
Rae Bareli	1,30,672	0.44	1,82,477	0.54	1,84,229	0.51
Sitapur	6,24,486	1.57	7,91,263	1.66	9,27,093	1.92
Hardoi	4,58,694	1.07	5,11,033	1.11	6,85,586	1.34
Kheri	6,76,784	1.66	12,56,791	2.64	16,79,597	3.20
Faizabad	3,66,783	1.06	6,32,568	1.66	6,40,878	1.65
Gonda	1,51,389	0.25	5,69,643	0.87	1,91,378	0.28
Bahraich	1,27,737	0.24	1,94,893	0.34	2,97,260	0.51
Sultanpur	2,24,943	0.70	3,28,698	0.97	3,26,416	0,94
Pratapgarh	1,28,610	0.50	1,65,519	0.62	2,02,484	0.73
Bara Banki	3,16,145	0.92	4,94,437	1.34	5,23,495	1.43
Uttar Pradesh	1,93,27,751	1.16	3,33,52,701	1.76	3,58,02,472	1.71

(a) <u>Temporal Comparisons in SNU Production</u>

Temporal comparisons can also be made with regard to assess the changes that have occurred in the production of SNU since 1950-51. It can be observed from Fig.38 that,

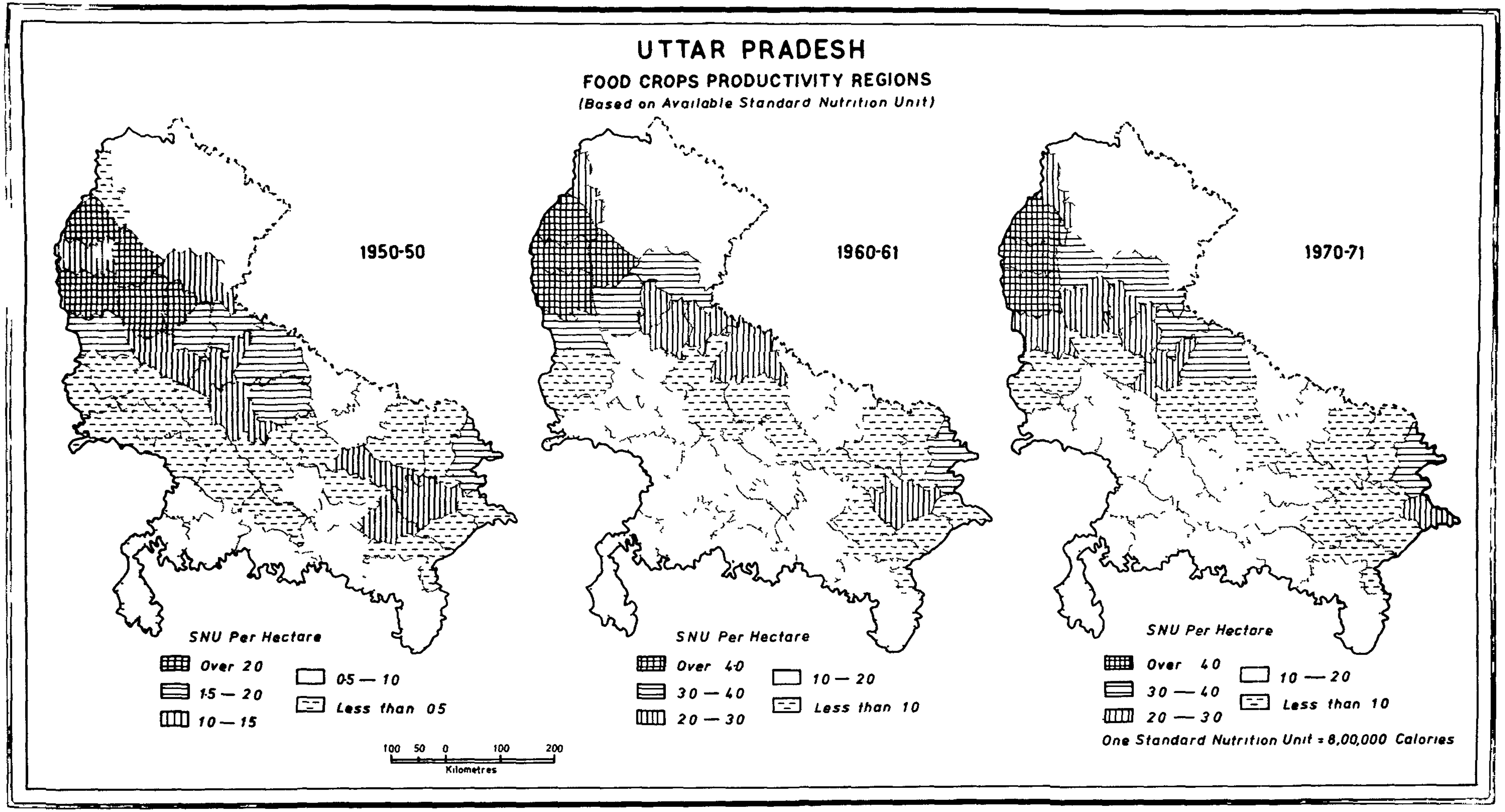
UTTAR PRADESH
FOOD CROPS PRODUCTIVITY REGIONS
(Based on Available Standard Nutrition Unit)
1950-50
1960-61
1970-71
SNU Per Hectare
Over 20
15 — 20
10 — 15
05 — 10
Less than 05
SNU Per Hectare
Over 40
30 — 40
20 — 30
10 — 20
Less than 10
SNU Per Hectare
Over 40
30 — 40
20 — 30
10 — 20
Less than 10
One Standard Nutrition Unit = 8,00,000 Calories
100 50 0 100 200
Kilometres

FIG. 38

in four districts of Saharanpur, Muzaffarnagar, Meerut and Bijnor the productivity of SNU doubled i.e., increased from 2 SNU per hectare to 4 SNU per hectare and even more than these figures from 1950-51 to 1960-61 (Table XIV). In other districts too, changes are to be seen. In the district of Dehra Dun for instance, during 1950-51 SNU produced as 0.89 per hectare and this figure rose to 2.38 SNU per hectare in 1960-61, Moradabad produced 2.00 to 3.30 SNU, and Rampur 2.02 to 2.46 SNU per hectare from 1950-51 to 1960-61 respectively. In four districts of Bareilly, Pilibhit, Kheri and Deoria the productivity of SNU per hectare rose between the range of 2 and 3 as compared to 1.50 and 2.00 during 1950-51. During this year (1950-51) the increase in the remaining districts remained either moderate or stagnant. For example, among the five districts of Trans-Ghaghara tract, the Gonda and Bahraich fell within the range of 0.5-1.0 SNU in 1950-51 and during 1960-61 it ranged between 1 and 2 SNU, and Gorakhpur and Basti had less than 0.5 SNU per hectare in 1950-51 which showed a figure of less than 1 SNU per hectare during 1960-61.

During 1970-71 in comparison to 1960-61 the SNU figures in each district show either a moderate change or a decrease. This situation reflects the pressure of population on agricultural land as well as limitations in availability of new land to be put under intensive agricultural uses. In this regard only few districts show a moderate rise in SNU production namely, Saharanpur from 4.24 to 4.46 SNU, Muzaffarnagar 7.77 to 8.16 SNU, Bijnor 4.65 to 5.29 SNU and Budaun 0.81 to 1.29 SNU from 1960-61 to 1970-71 respectively in western parts of the State. The extent of decrease in SNU production in the remaining districts can easily be identified from Table XIV.

It can easily be summarised from the above discussion that, the availability of SNU per hectare show a steep rise during 1960-61 as compared to 1950-51.

(b) Growth Rate in Standard Nutrition Unit Productions

Growth rates in production of SNU per hectare/ per annum have been computed for both the decades. Between 1950-51 and 1960-61 decennial years, the districts of Gonda, Naini Tal, Basti and Dehra Dun recorded the highest average growth rate as 12.30 per cent, 11.79 per cent, 8.15 per cent and 8.19 per cent per annum respectively, followed by five districts namely, Gorakhpur, Mathura, Ghazipur, Aligarh, and Deoria which fall within the range of growth between 6 and 7 per cent. The next range of growth rate between 4 and 6 per cent comprises ten districts of Azamgarh, Muzaffarnagar, Saharanpur, Bulandshahr, Agra, Moradabad, Ballia, Bijnor, Allahabad and Kheri. The districts of Meerut, Bareilly, Fatehpur, Faizabad and Pilibhit recorded the growth rates between the range of 3 and 4 per cent per annum. Among the nine districts namely, Jaunpur, Varanasi, Bara Banki, Jhansi, Shahjahanpur, Kanpur, Mirzapur, Sultanpur and Mainpuri the growth rate figures ranged between 2 and 3 per cent per annum. Three districts of Bundelkhand region namely, Jalaun, Hamirpur and Banda, and Rampur from Rohilkhand recorded the growth between 1 and 2 per cent. Six districts namely, Sitapur, Etawah, Farrukhabad, Rae Bareli, Lucknow and Bahraich have show a very slow growth, therefore, fall within the range less than 1 per cent per annum. During this period five districts recorded negative growth, and they are namely, Budaun -3.55 per cent, Unnao -1.51 per cent, Etah -0.64 per cent, Hardoi and Pratapgarh -0.54 and 0.32 per cent per annum respectively.

During the period between 1960-61 and 1970-71 the growth rate figures relating to SNU production in each district are rather discouraging i.e., most of the districts recorded and attained a low level as compared to the previous years. Two different aspects may be observed from the growth figures in this period. First aspect relates to the slow level of growth, and the second is the negative rate of growth. Among others, only five districts show a grow above 2 per cent in the districts of Budaun, Bahraich, Etah, Hardoi and Kheri, the highest being in Budaun as 5.15 per cent and the lowest being in Kheri as 2.33 per cent per annum. The districts having growth range between 1 and 2 per cent are Pratapgarh, Lucknow, Naini Tal, Sitapur, Pilibhit, Bijnor, Shahjahanpur, Kanpur, Bara Banki and Farrukhabad. There are fourteen districts in the State where the growth recorded less than 1 per cent per annum (Appendix X).

Besides these, ten districts namely, Gonda, Bulandshahr, Agra, Mathura, Aligarh, Allahabad, Basti, Azamgarh, Deoria and Moradabad recorded a negative growth from -1.00 per cent and onwards. And the remaining eight districts namely, Etawah, Mainpuri, Unnao, Jaunpur, Ballia, Rampur, Bareilly and Meerut show the negative growth varying between -0.01 and -1.00 per cent.

C. Regional Differences in Food Crops Productivity - Based on Output Per Hectare

Productivity of agriculture can also be looked into while considering the output per hectare of cropped land in relation to wholesale/harvest crop prices in the study area, as well as the corresponding year.[8] Therefore, an attempt has been made to compute price-weighted output per hectare considering the average wholesale prices prevailed in the State during the corresponding years. The cropwise price indices are given in Table XV.

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8. Nangia, S., et al., "Variations in Field Productivity - A Case Study of Khandewala, Haryana", op. cit., pp.12-14.

Districtwise details of output per hectare measured in monetary terms are produced in Table XVI for three different points of time. The districts arranged in different output groups are shown in Fig.39 accordingly.

TABLE XV

Average wholesale prices of different food crops in U.P.

Name of crop	1950-51	1960-61	1970-71
Rice	53.0	64.0	121.0
Jowar	31.0	32.0	67.0
Bajra	32.0	38.0	70.0
Maize	30.0	32.0	63.0
Wheat	45.0	45.0	86.0
Barley	29.0	31.0	58.0
Gram	33.0	37.0	91.0
Arhar	43.5	44.0	118.0
Pulses	46.8	52.5	113.6
Oilseeds	71.6	65.3	159.1
Sugarcane	8.5	10.5	12.5
Potato	21.0	37.5	53.0

Source: Office records State Agricultural Marketing Office, Uttar Pradesh, Lucknow.

It can be observed from Table XVI and Fig.39 that, during 1970-71 the output received per hectare by the farmers was highest in the five districts of Muzaffarnagar, Meerut, Bijnor, Deoria and Naini Tal, which accounted to more than

Rs.5,000 per hectare. This is worth mentioning that, except Naini Tal, these four districts belong to sugarcane growing belt of the State. In the second order of output five districts namely, Moradabad and Shahjahanpur from Rohilkhand region, Gorakhpur and Trans-Ghaghara tract and three districts Jaunpur, Pratapgarh and Sultanpur represent eastern region fall within the output range between Rs.4,700 and 5,000 per hectare. There are eight other districts which belonged to the third or medium category. They are namely Dehra Dun, Saharanpur, Agra, Mainpuri, Rampur, Bareilly, Pilibhit, and Hardoi where the figures of output ranged between Rs.4,500 and 4,700 per hectare. Between the range of output Rs.4,200 and 4,500 are categorised four districts namely, Etah, Farrukhabad, Etawah and Kanpur from Doab region, Gonda and Basti forming the parts of Trans-Ghaghara region, Lucknow and Bara Banki from the central region, and Mirzapur and Ghazipur representing the southeastern part of the State. Among the districts where productivity of land varies from Rs.4,000 to Rs.4,200, four belong to Doab region namely, Bulandshahr, Mathura, Fatehpur and Allahabad, Budaun from Rohilkhand region, Banda from Bundelkhand region, Varanasi and Azamgarh from the eastern region, and Kheri, Bahraich and Sitapur belong to northeastern parts of the State. In the remaining six districts, Aligarh belongs to Doab, Jalaun, Hamirpur and Jhansi from Bundelkhand

TABLE XVI

Districtwise output per hectare in U.P.

(Figures in Rs.)

Name of district	1950-51	1960-61	1970-71
1	2	3	4
Dehra Dun	1759.09	1803.72	4512.83
Saharanpur	1567.77	1903.02	4755.56
Muzaffarnagar	1572.60	2145.45	5409.58
Meerut	1566.38	2031.19	5292.16
Bulandshahr	1403.71	1980.48	4009.68
Aligarh	853.65	1375.56	3257.54
Mathura	1104.58	1854.31	4142.57
Agra	1111.34	1773.18	4524.00
Mainpuri	1024.52	1768.89	4635.94
Etah	1151.71	1013.06	4322.47
Bareilly	1243.95	1766.93	4538.03
Bijnor	1471.03	1892.34	5079.58
Budaun	1328.81	1011.27	4200.77
Moradabad	1481.84	2038.77	4985.42
Shahjahanpur	1310.48	1755.79	4842.44
Pilibhit	1256.25	1575.27	4678.71
Rampur	1467.61	1575.58	4739.36
Farrukhabad	1000.86	1323.25	4261.12
Etawah	1226.29	2150.26	4398.93
Kanpur	1222.14	2180.33	4341.08
Fatehpur	1079.25	2164.54	4228.74
Allahabad	877.71	2138.35	4173.39
Jhansi	987.30	1627.46	3632.20
Jalaun	1085.01	1614.37	3687.36
Hamirpur	962.26	1620.56	3684.50
Banda	857.17	1316.86	3682.29
Varanasi	884.84	1471.94	4191.69

(contd....)

TABLE XVI (Contd...)

1	2	3	4
Mirzapur	1209.78	1662.05	4425.34
Jaunpur	1124.58	2058.19	4839.48
Ghazipur	699.84	1688.06	4508.79
Ballia	1104.91	1826.52	4529.56
Gorakhpur	1164.15	2093.20	5538.46
Deoria	1238.59	1802.08	4987.69
Basti	1054.96	1909.79	4454.84
Azamgarh	1104.87	1869.06	4142.03
Naini Tal	1236.98	2173.44	5050.47
Lucknow	1304.83	1591.66	4287.52
Unnao	1262.61	1714.58	3765.92
Rae Bareli	1336.36	1736.19	3821.76
Sitapur	1348.97	1507.57	4172.26
Hardoi	1139.45	1598.33	4772.99
Khori	1243.49	1430.74	4033.08
Faizabad	1145.40	1986.11	4627.19
Gonda	1152.61	1476.52	4405.51
Bahraich	1390.36	1410.49	4208.80
Sultanpur	1333.18	1885.71	4775.72
Pratapgarh	1036.70	1844.70	4829.56
Bara Banki	1006.71	1720.76	4281.94
Uttar Pradesh	1106.59	1755.60	4650.35

region and both Unnao and Rae Bareli are from central part of the State, where the output ranged less than Rs.4,000 per hectare.

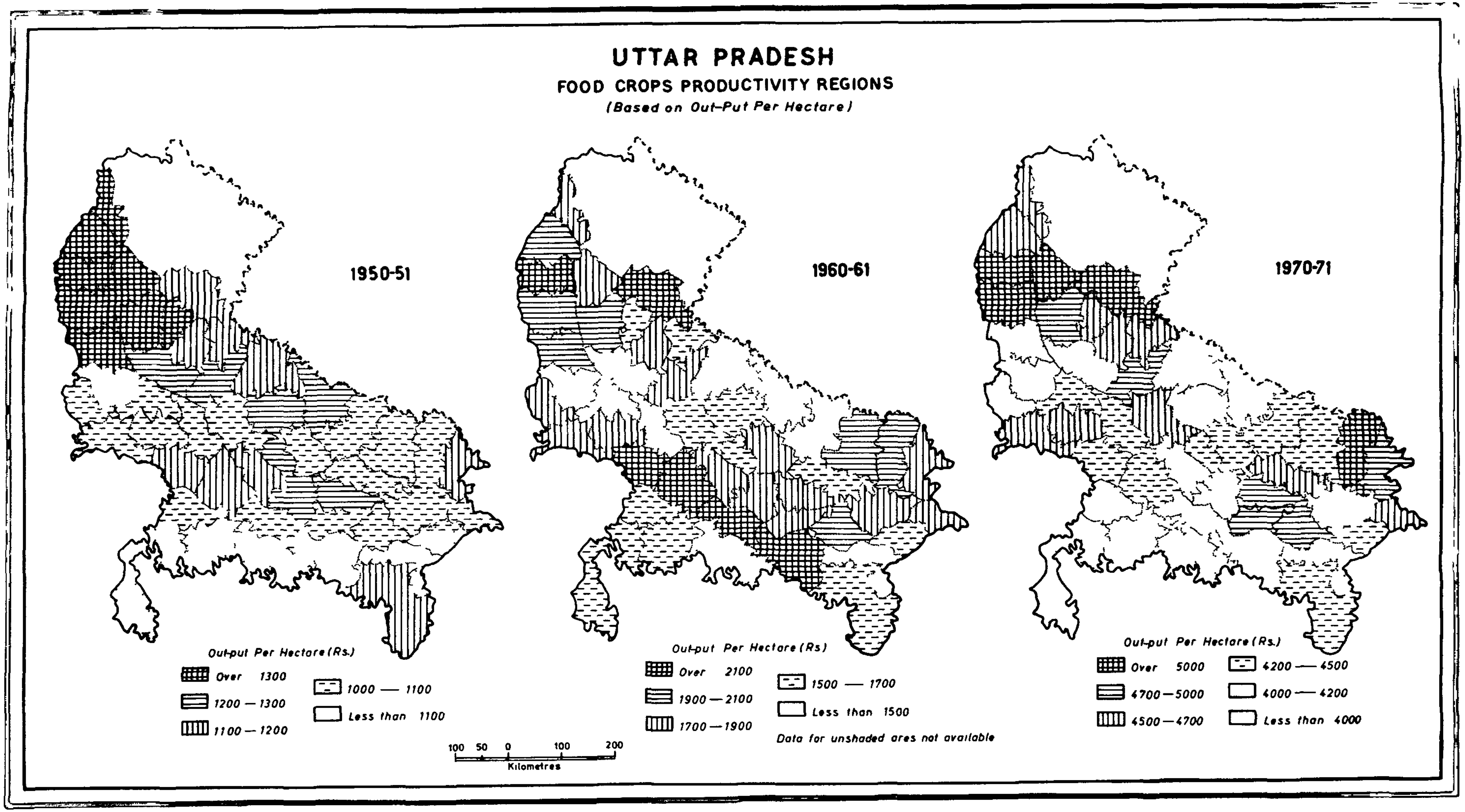
UTTAR PRADESH
FOOD CROPS PRODUCTIVITY REGIONS
(Based on Out-Put Per Hectare)
1950-51
1960-61
1970-71
Out-put Per Hectare (Rs.)
Over 1300
1200 — 1300
1100 — 1200
1000 — 1100
Less than 1100
Out-put Per Hectare (Rs)
Over 2100
1900 — 2100
1700 — 1900
1500 — 1700
Less than 1500
Data for unshaded ares not available
Out-put Per Hectare (Rs.)
Over 5000
4700 — 5000
4500 — 4700
4200 — 4500
4000 — 4200
Less than 4000
100 50 0 100 200
Kilometres

FIG. 39

(a) <u>Temporal Comparisons in Productivity Indices</u>

In case of productivity variations in terms of output per hectare interesting changes can be seen from the Table XVI, as well as from tho Fig.39 during the study period. Since 1950-51 there are continuous variations in productivity. During 1950-51 eight northwestern districts namely, Dehra Dun, Saharanpur, Muzaffarnagar, Meerut, Bulandshahr, Bijnor, Moradabad and Rampur accounted tho highest returns per hectare of cropped land i.e., more than Rs.1,300. In 1960-61, four districts lower Doab and Muzaffarnagar of upper Doab including the Naini Tal ranked first in respect of output ranged more than Rs.2,100 per hectare. During 1970-71, the highest productivity ranged more than the value of Rs.5,000 in the districts of Muzaffarnagar, Meerut, Bijnor, Naini Tal and Gorakhpur.

In the second category of output range Rs.1,200-1,300 per hectare the districts were scattered in small pockets, mainly in the central part of the State. During 1960-61 this category with the output range Rs.1,900-2,100 per hectare restricted to three districts of upper Doab namely, Saharanpur, Meerut and Bulandshahr, one district Moradabad of Rohilkhand, two districts Basti and Gorakhpur of Trans-Ghaghara tract and Jaunpur among the eastern districts. This category during 1970-71 with the output range between Rs.4,700 and Rs.5,000 per hectare was further diversified by comprising three districts of Jaunpur, Sultanpur and Sultanpur from eastern part, Deoria from Trans-Ghaghara tract, Shahjahanpur and Moradabad from Rohilkhand region.

Considerable changes within the districts classified under third category are to be seen during 1950-51 and 1960-61. The districts of Etawah and Kanpur show an increase in output from Rs.1,100-1,200 in 1950-51 to Rs.1,700-1,900 per hectare in 1960-61. And during 1960-61 to 1970-71 the increase in this category recorded in the districts of Agra and Mainpuri as between Rs.1,700-1,900 and Rs.4,500-4,700. Districts of Rampur, Bareilly and Pilibhit attained the output between Rs.1,700-1,900 during 1960-61 to Rs.4,200-4,500 per hectare in 1970-71.

(b) <u>Growth Rate in Output Per Hectare</u>

Rate of increase computed for 1950-51 to 1960-61 shows the highest growth rate in output per hectare in the six districts of Allahabad, Ghazipur, Fatehpur, Jaunpur, Basti and Gonda which is more than 6 per cent per annum. The growth rate ranges between 5 and 6 per cent in the thirteen districts and between 4 and 5 per cent exhibited in the four districts of Agra, Banda, Etah and Jalaun. Among the nine districts the growth rate ranges between 3 and 4 per cent and they are namely, Deoria, Bareilly, Hardoi, Bulandshahr, Sultanpur, Mirzapur, Muzaffarnagar, Unnao and Moradabad. Below the range of growth of 3 per cent fall the remaining fourteen districts, and the Budaun district shows the negative growth being -2.69 per cent (Appendix X).

Between the years 1960-61 and 1970-71 the highest growth rates more than 11 per cent are recorded in eight districts, viz., Budaun, Farrukhabad, Rampur, Hardoi, Pilibhit, Gonda, Bahraich and Varanasi. The growth rate between 9 and 10 per cent covers the twelve districts namely, Kheri, Sitapur, Deoria, Shahjahanpur, Banda, Gorakhpur, Lucknow, Ghazipur, Bijnor, Mainpuri, Pratapgarh, Mirzapur and Meerut. The eleven districts namely, Bareilly, Agra, Sultanpur, Etah, Muzaffarnagar, Dehra Dun, Saharanpur, Ballia, Bara Banki, Moradabad and Mainpuri recorded growth between 8 and 9 per cent. The remaining sixteen districts show a growth rate of less than 8 per cent per annum.

D. Regional Differences in Food Crops Productivity - Based on Output Per Worker

It would be worthwhile to ascertain the productivity of labour in agricultural production, as productivity of land is mainly associated with the total level of food production per hectare, on the other hand the productivity of labour determines the income or gain of the farmer engaged in agriculture in time or space.

The labour productivity can be obtained either by dividing the gross production in any unit area by the number of man-hours or less precisely by the number of persons employed in agriculture. The index can either be obtained to the gross production by dividing it by the number of workers engaged in agriculture or it can reversely be applied where the total number of workers per unit of production is assessed.[9] Further, it can also be attempted to get gross output per worker by using price-weighted volume of gross agricultural production.[10] The same approach is adopted by Yates, while evaluating the labour productivity differences in western Europe.[11]

In order to assess the total income of the farmer engaged in agriculture, an attempt has been made to comput output per agricultural worker in the districts of Uttar Pradesh for the same periods of study mentioned earlier. Table XVII shows the districtwise output in Rs. per agricultural worker for three decennial years. Fig.40 shows a group of districts under a specific range of output per agricultural worker. The total population of agricultural workers incorporated to compute the productivity in each district for the three corresponding years appears in Appendix XI.

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9. Shafi, M., "Approaches to the Measurement of Agricultural Efficiency", Proceedings of the Summer School in Geography, Naini Tal (Unpublished), Aligarh, 1965, p.4.
10. F.A.O., Smaller Farmlands Can Yield More, Rome, 1969, pp.7-8.
11. Yates, P.L., Food Land and Manpower in Western Europe (London, 1960), pp.147-63.

TABLE XVII

Districtwise output per agricultural worker in U.P.

(Figures in Rs.)

Name of district	1950-51	1960-61	1970-71
1	2	3	4
Dehra Dun	651.1	1520.2	4271.7
Saharanpur	3057.4	6390.4	12217.4
Muzaffarnagar	4014.8	8543.9	19086.1
Meerut	3492.6	7235.1	16586.6
Bulandshahr	1668.7	4007.8	6033.4
Aligarh	546.7	1664.1	2795.0
Mathura	802.9	2174.4	4232.6
Agra	398.3	988.0	1424.9
Mainpuri	414.5	784.8	1483.2
Etah	566.1	824.2	2164.9
Bareilly	1136.7	2374.5	5344.7
Bijnor	3216.1	6239.7	15873.2
Budaun	817.8	800.6	2977.8
Moradabad	1533.9	3248.8	7259.9
Shahjahanpur	1036.7	2029.2	5393.5
Pilibhit	1560.5	3698.9	9793.8
Rampur	1528.8	2942.2	6183.9
Farrukhabad	508.8	765.5	1967.0
Etawah	482.8	915.7	1794.9
Kanpur	404.5	742.3	1586.7
Fatehpur	414.9	607.8	1586.4
Allahabad	259.3	380.5	872.3
Jhansi	311.3	499.7	1249.4
Jalaun	458.1	556.8	1581.9
Hamirpur	527.7	580.0	1437.7
Banda	546.2	511.4	1130.4
Varanasi	476.7	763.7	2198.8

(contd....)

TABLE XVII (Contd...)

1	2	3	4
Mirzapur	413.0	514.8	1089.4
Jaunpur	579.2	818.8	2551.0
Ghazipur	355.1	752.6	2421.6
Ballia	600.7	1068.9	2607.5
Gorakhpur	320.0	754.0	2389.9
Deoria	822.1	1866.8	5531.4
Basti	345.7	727.5	2134.6
Azamgarh	526.9	1168.4	2951.8
Naini Tal	816.8	3594.1	13271.9
Lucknow	167.7	414.8	1166.2
Unnao	496.3	567.8	1443.5
Rae Bareli	265.3	340.2	903.2
Sitapur	949.0	1453.5	3928.4
Hardoi	684.2	953.0	2994.9
Kheri	1304.8	2898.7	8923.1
Faizabad	578.0	1036.4	2907.8
Gonda	179.2	647.4	615.1
Behraich	196.0	326.3	1170.2
Sultanpur	404.9	608.7	1621.6
Pratapgarh	263.8	300.9	1112.0
Bara Banki	557.2	892.5	2480.2
Uttar Pradesh	867.87	1569.41	4223.81

Productivity based on labour output during 1970-71 was concentrated highly in the eight north and northwestern districts of the State. Threo of them namely, Saharanpur, Muzaffarnagar and Meerut are of Doab region two districts of Bijnor and Moradabad of Rohilkhand, Pilibhit and Kheri forming the Tarai region and Naini Tal from sub-Montane region fall

UTTAR PRADESH

FOOD CROPS PRODUCTIVITY REGIONS

(Based on Out-Put Per Agricultural Worker)

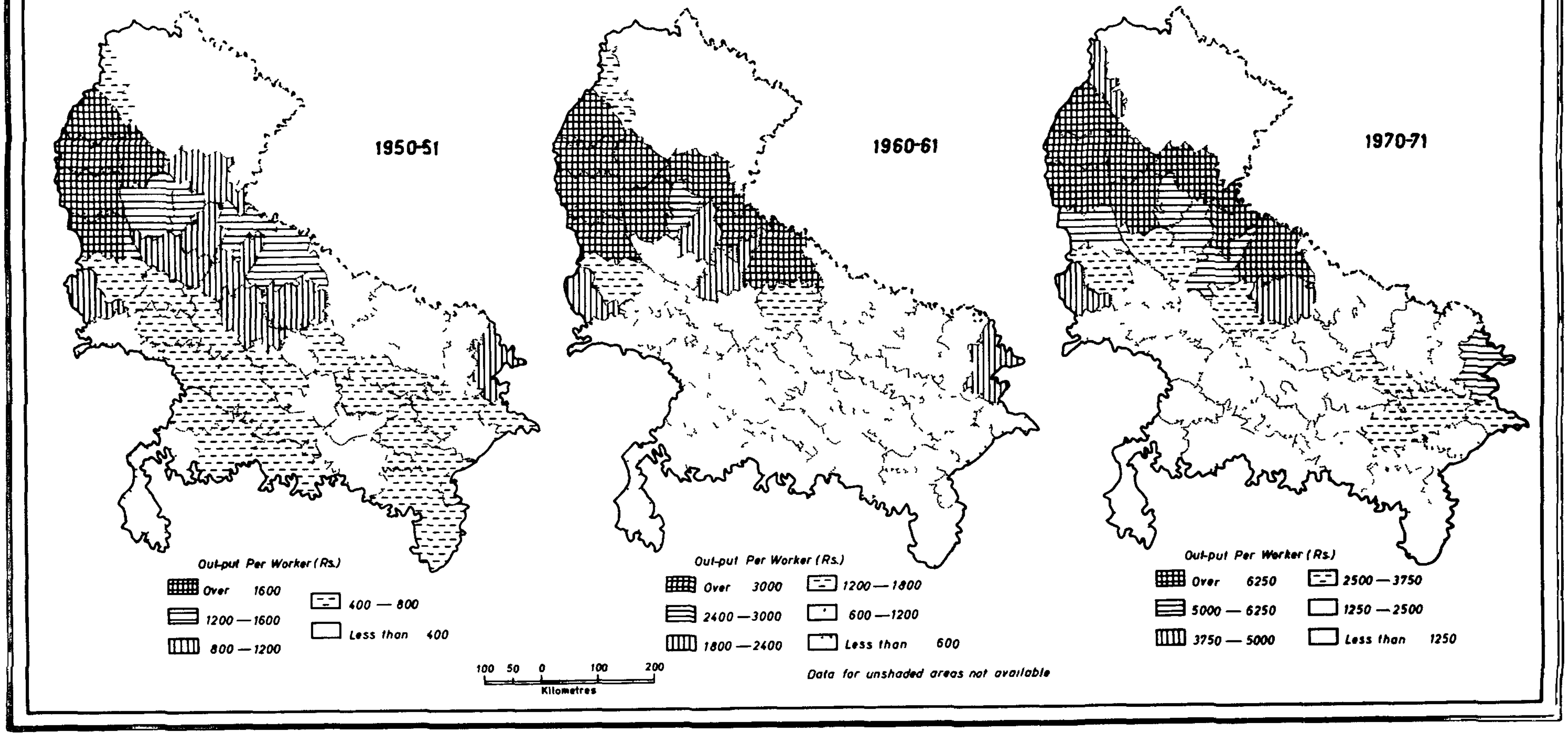

FIG. 40

in the category where the output or the gain of farmer ranged more than Rs.6,250. Between the output range of Rs.5,000 and Rs.6,250 per worker are the five districts; three of them namely, Rampur, Bareilly and Shahjahanpur belong to Rohilkhand region, and each Bulandshahr and Deoria represents Doab and Trans-Ghaghara regions respectively. Only two districts of Mathura and Sitapur belonged between the range of Rs.3,750 and Rs.5,000 per agricultural worker. The fourth category of districts where a worker gets Rs.2,500-3,750 includes Faizabad, Azamgarh, Jaunpur and Ballia of eastern part Aligarh and Budaun of Doab and Rohilkhand regions respectively, and district of Hardoi representing the central part of the State. There is a large concentration of districts which belong between the range of output Rs.1,250 and Rs.2,500 per worker. Among them, seven belong to middle and lower Doab, and two are from Trans-Ghaghara tract, the districts of Ghazipur and Varanasi represent the eastern part, three Unnao, Bara Banki and Sultanpur districts constitute the central part and in Bundelkhand tract lie the remaining two districts namely, Jalaun and Hamirpur. The four southernmost districts extending from Jhansi to Mirzapur, excluding Hamirpur are the districts where farmers output is less than Rs.1,250. Two districts of Trans-Ghaghara namely, Gonda and Bahraich, and three districts of Lucknow. Rae Bareli and Pratapgarh too, fall within the sixth category of productivity index.

(a) Temporal Comparisons in Productivity Indices

The temporal changes in respect to output per worker between the decennial years 1950-51 and 1960-61 can be observed in the four districts, viz., Moradabad, Naini Tal, Pilibhit and Kheri further diversified and enhanced upto more than Rs.3,000 in 1960-61 as compared to the range of output Rs.1,600 per worker during 1950-51. The output per worker in them during 1950-51 was between Rs.1,200 and Rs.1,600 and during 1960-61 it rose upto between Rs.2,400 and Rs.3,000. In three districts of Bareilly, Shahjahanpur and Deoria the output range per worker extended upto Rs.1,800-2,400 during 1960-61 as compared to Rs.1,200-1,600 in 1950-51 (Fig.40). Two districts of Dehra Dun and Aligarh belonging to the fourth category show the figures between the range of Rs.1,200 and Rs.1,800 during 1960-61 as compared to the range Rs.400-800 per worker in 1950-51. The fifth category indicates the districts where the output per worker was less than Rs.400, and these districts were further diversified to be included in the sixth category and the output range rose upto Rs.600-1,200 in the districts falling in fifth category, and Rs.600 and less than this figure for the sixth category.

The output per worker rose further during the decennial years 1960-61 and 1970-71. The position of districts on the map remained more or less the same during 1970-71 as that it was during 1960-61. But the output figures doubled itself per worker almost in all the ranking groups in the State during 1970-71.

(b) Growth Rate in Output Per Worker

The growth rate relating to output per agricultural worker State as a whole shows an increase of 4.82 per cent during the period between 1950-51 and 1960-61, and an increase of 10.76 per cent per annum between 1960-61 and 1970-71. The districtwise growth rate between 1950-51 and 1960-61 is rather diversified. In the thirteen districts namely, Naini Tal, Aligarh, Basti, Mathura, Bulandshahr, Agra, Pilibhit, Lucknow, Gorakhpur, Dehra Dun, Deoria, Azamgarh and Hardoi have recorded growth at the rate of more than 8 per cent per annum. Besides these, there are fourteen districts where the growth ranged between 6 and 8 per cent. Among them are namely, Ghazipur, Muzaffarnagar, Moradabad, Saharanpur, Meerut, Bareilly, Basti, Shahjahanpur, Bijnor, Mainpuri, Rampur, Etawah, Kanpur and Faizabad. In the eight districts, viz., Ballia, Bahraich, Bara Banki, Jhansi, Varanasi, Sitapur, Farrukhabad and Sultanpur the growth rate was observed between 4 and 6 per cent per annum. Among the remaining thirteen districts during this period the growth rate lies less than 4 per cent in the eleven districts, and two districts of Budaun and Banda show negative growth i.e., -0.21 per cent and -0.65 per cent respectively (Appendix X).

Between the years 1960-61 and 1970-71 the growth rate is again in diversified manner, although the same figures of growth are recorded. The four districts of Budaun, Naini Tal, Pratapgarh, and Bahraich show growth more than 13 per cent per annum. There are other eleven districts where the growth rate of output per worker is between 11 and 13 per cent. Most of these districts fall in the eastern parts of the State. The twelve districts of Jalaun, Lucknow, Faizabad, Rae Bareli, Sitapur, Dehra Dun, Bara Banki, Etah, Sultanpur, Shahjahanpur, Pilibhit and Fatehpur show growth rates between 9 and 11 per cent. In the thirteen districts, viz., Unnao, Azamgarh, Hamirpur, Ballia, Jhansi, Farrukhabad, Bijnor, Muzaffarnagar, Meerut, Banda, Moradabad, Allahabad and Bareilly the growth was recorded between 7 and 9 per cent per annum. Except the district of Gonda, the remaining nine districts fall below the growth rate of 7 per cent. During 1960-61 to 1970-71 the growth rate in Gonda was recorded as negative i.e., -0.50 per cent.

(c) Inter-district Comparisons of Land and Labour Productivity

The land and labour productivity in terms of money is shown in the Tables XVI and XVII and was calculated as output per hectare of cropped land and per agricultural worker for the last three corresponding decennial years. The inter-district variations are indeed very great as the same can be varified from both the tables. Output per hectare computed ranged from Rs.3,632.20 (Jhansi) to Rs.5,409.58 (Muzaffarnagar), and output per agricultural workor from Rs.615.10 (Gonda) to Rs.19,085.10 (Muzaffarnagar) during 1970-71. The similar figures relating to productivity differences may be cited for the subsequent decennial years 1950-51 and 1960-61.

The land and labour productivity indices for the fortyeight districts of the State are shown in Fig.41. Labour productivity has been measured on the Y/L vertical axis and land productivity on Y/A horizontal axis seperately for the decennial years (Fig.41-A, 1950-51; Fig.41-B, 1960-61; and Fig.41-C, 1970-71). During the corresponding years seperately, three distinct scatters or paths extending out from the origin can be observed: (i) the path indicated by a group of districts where the extent of relationship between both the outputs is quite good, particularly in four districts of Muzaffarnagar, Meerut, Bijnor and Saharanpur; (ii) the path indicated by the districts among the others, viz., Gonda, Bahraich, Allahabad, Lucknow, Rae Bareli, Sultanpur and Pratapgarh etc., where the land-labour productivity has unfabourable extent of relationship; (iii) the path indicated by the districts among the others, viz., Bulandshahr, Moradabad, Pilibhit, Rampur, Bareilly, Shahjahanpur, Kheri and Deoria etc., in which the relative productivity indices

INTER-DISTRICT COMPARISONS OF LAND AND LABOUR PRODUCTIVITY IN UTTAR PRADESH

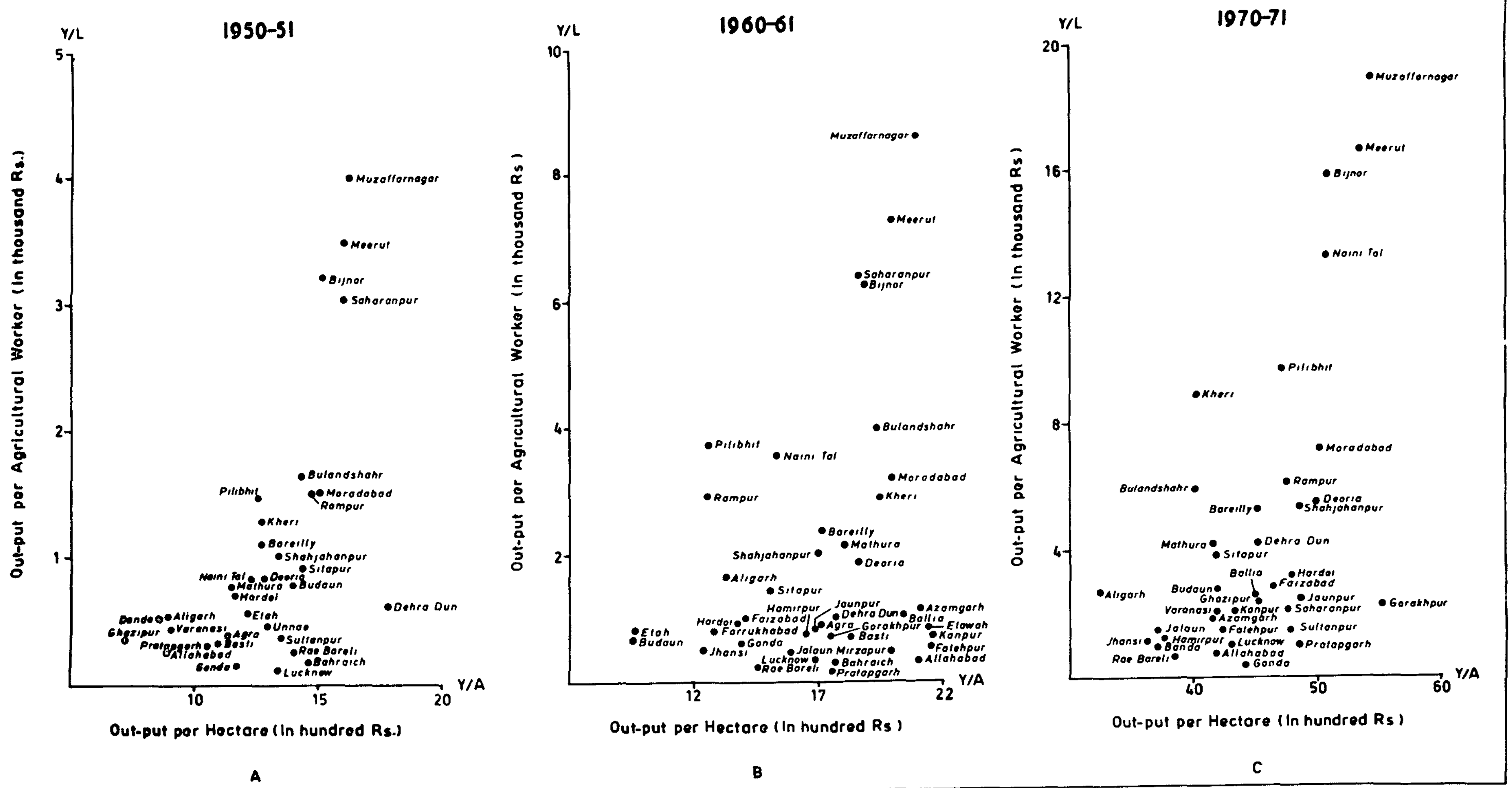

FIG. 41

are in between the other two groups. These relationships may be visualized by comparing Fig.41-A, Fig.41-B, and Fig.41-C. Each path seems to reflect the long-run process of agricultural growth in respect of land and labour output in each district which form a part of certain region in the State.

CHAPTER VIII

WATER USE AND IRRIGATION

Crop growth and production subsequently depend to a greater extent on the availability of water and its proper use. It has been realised from a number of researches in the recent years that the effect of irrigation on crop productivity is such, that if 10 per cent of cropped land is properly irrigated that may roughly be estimated to contribute about 20 per cent of agricultural production.[1] When we are concerned with the expansion of irrigated areas in order to increase agricultural productivity, the same can be achieved by increasing the yield of crops on the same lands that have already received irrigation. However, an additional improvement in irrigation efficiency can make it possible to get double or triple production in many irrigated areas. Therefore, it is advocated that assured and controlled water supplies are one of the essential requirements for the achievement of the full potential of the new high-yielding varieties of cereals.

A. Sources of Irrigation

The State of Uttar Pradesh being large in size possesses a number of irrigation sources that have been

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1. F.A.O., Smaller Farmlands Can Yield More, Rome, 1969, p.19.

determined by its physical features like topography, geology, ground water-table and its quality etc.[2] Generally speaking sources of irrigation constitute two forms; irrigating land by taping sub-soil water through wells, tube-wells and pumps, and by serving surface water by canals, tanks (including lakes and ponds), and reservoirs. Therefore, the following irrigation sources have been developed in the State e.g., canals, tube-wells, tanks (including lakes and ponds), and other sources. The respective share of each source in the State is shown in Table XVIII. The figures produced in the table pertain to three different decennial years i.e., 1950-51, 1960-61 and 1970-71. It is evident from the table that, among all the sources, three major sources, viz., canal, tube-well and other well altogether irrigate more than 90 per cent of the net irrigated area of the State (1970-71). Next to canal, tube-well irrigation constitutes the second place. It is also noticeable from the table that, the extent of irrigation by the above sources follow a quite significant increase during the subsequent decennial years. A general trend of increase follows in net irrigated area of about 0.23 million hectares between the periods 1950-51 and 1960-61 and about 1.74 million hectares during 1960-61 to 1970-71.

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2. For details on this aspect see, Agarwal, R.R., et al., "Quality of Irrigation Waters in Uttar Pradesh", Indian Journal of Agricultural Science, Vol.XXVI, Part IV, 1956, pp.361-71.

TABLE XVIII

Details of sourcewise irrigation in U.P. - A trend of progress

(Area in hectares)

Year	Canals	Tube-wells	Other wells	Reser-voirs	Tanks lakes and ponds	Other sour-ces	Net irri-gated area	Area irrigated more than once	Gross irri-gated area
1	2	3	4	5	6	7	8	9	10
1950-51	18,47,122 (38.40)	2,76,287 (5.74)	19,05,162 (39.61)	5,813 (0.14)	included in other sources	7,74,966 (16.11)	48,09,350 (92.86)	3,69,558 (7.13)	51,78,908 (26.89)
1960-61	19,92,580 (39.50)	5,43,279 (10.77)	18,43,844 (36.55)	2,560 (0.05)	4,19,069 (8.33)	2,42,744 (4.81)	50,44,076 (91.23)	4,84,381 (8.76)	55,28,457 (26.29)
1970-71	24,22,663 (35.68)	19,65,248 (28.97)	18,26,406 (26.90)	1,489 (0.02)	3,59,914 (5.30)	2,12,471 (3.13)	67,88,191 (86.05)	11,00,166 (13.94)	78,88,357 (35.57)

Note: Figures in parenthesis for columns 2 to 7 refer as percentages to the net sown area, for columns 8 and 9 to the gross irrigated area and for column 10th to the cropped area of the State.

Source: Bulletin of Agricultural Statistics for U.P. 1970-71, Directorate of Agriculture, U.P., Lucknow, 1972.

But their relative ratios from gross irrigated area follow negative trend of increase i.e., -1.63 and -5.18 per cent respectively. These negative trends may have been duo to additional cultivable lands brought under use whereas, in due course the irrigation facilities have not kept pace to tho required needs. In both the categories the figures of area irrigated moro than once, and gross irrigated aroa, show an interesting increases, more particularly betweon the periods 1960-61 and 1970-71, in which major programmes for enhancing the agricultural production were launchod by the State Govornment, thoroforo, figures havo recorded an abrupt shift in the relative shares from 8.76 to 13.94 per cont and from 26.29 to 35.57 per cent rospectively (Table XVIII).

Beforo reviewing the districtwise details on irrigation, let us have a look on rainfall distribution pattern in different parts of the State. Table XIX shows the average rainfall spread over in different physical divisions of the State during 1970-71. Although there were considerable variations in rainfall distribution pattern in different parts but, the year may be regarded as the year of normal rainfall. The highest rainfall accounted in the Sub-Montane tract lying in between the Montane tract and Gangetic plains, the average recorded about 1,400 mm., and next to it was the Montane tract. Among the other sub-regions of the Gangetic plains; Ganga-Gomti interfluve and Tran-Ghaghara

TABLE XIX

Average rainfall distribution in different physical division in U.P. - 1970-71

Physical division	Average rainfall received in mm.
I. Montane Tract	1,316.24
II. Sub-Montane Tract	1,385.20
III. Gangetic Plains	
(a) Ganga-Yamuna Doab	827.89
(b) Ganga-Gomti Interfluve	1,147.48
(c) Gomti-Ghaghara Doab	857.65
(d) Trans-Ghaghara Tract	1,190.10
(e) Rohilkhand Tract	821.52
IV. Bundelkhand Tract	886.47

tract experienced rainfall between the range of 1,100 and 1,200 mm. and in the remaining regions the average rainfall recorded between the range of 800 and 900 mm. (Table XIX).

Table XX shows sourcewise irrigated area (in percentages) under the three broad heads i.e., proportion of canals irrigation, tube-wells and other sources (including other wells, reservoirs, tanks, lakes and ponds, and other means), and intensity of irrigation with respect to net irrigated area, area irrigated more than once and gross

TABLE XX

Districtwise details of irrigation in U.P. -1970-71

(Figures in percentages)

Name of district	Canals	Tube-wells	Other* sources	Net irrigated area	Area irrigated more than once	Gross irrigated area
1	2	3	4	5	6	7
Dehra Dun	48.55	4.75	46.67	60.49	65.29	33.16
Saharanpur	44.59	42.36	13.02	76.07	31.44	44.27
Muzaffarnagar	52.89	37.53	9.56	73.30	36.40	71.55
Meerut	43.79	40.03	16.15	69.45	43.98	77.82
Bulandshahr	31.38	43.91	24.69	76.14	31.32	66.09
Aligarh	32.64	43.37	23.97	79.70	25.46	65.27
Mathura	61.52	25.14	13.32	89.79	11.36	54.72
Agra	37.96	39.61	22.40	94.92	5.34	37.58
Mainpuri	38.25	26.10	35.62	90.17	10.89	52.09
Etah	38.12	24.15	37.70	83.19	20.20	48.80
Bareilly	62.68	11.91	25.39	83.07	20.36	32.85
Bijnor	7.20	74.46	18.32	86.69	15.35	31.23
Budaun	-	50.05	49.93	90.83	10.09	33.28
Moradabad	1.80	43.51	54.67	88.13	13.46	38.19
Shahjahanpur	39.38	30.09	30.50	82.25	21.08	27.63
Pilibhit	67.93	24.12	7.93	82.25	21.57	26.46
Rampur	42.83	41.91	15.23	74.28	34.62	20.84
Farrukhabad	22.97	46.66	30.34	86.28	15.89	38.31
Etawah	61.44	13.37	25.16	87.02	14.90	43.04
Kanpur	73.70	13.39	12.89	89.74	11.43	30.94
Fatehpur	42.55	5.07	52.35	91.28	9.54	27.08
Allahabad	31.83	26.80	41.70	89.63	11.56	23.77
Jhansi	55.46	0.15	44.36	96.69	3.32	19.37
Jalaun	99.02	0.10	0.86	96.25	3.88	32.50
Hamirpur	90.30	0.21	9.47	98.80	1.09	15.73
Banda	98.32	0.64	1.03	87.78	12.16	16.20

(contd....)

TABLE XX (Contd...)

1	2	3	4	5	6	7
Varanasi	31.26	19.49	49.23	87.78	14.47	22.81
Mirzapur	72.83	6.05	21.09	92.03	8.65	35.31
Jaunpur	7.33	45.92	46.72	96.08	4.07	30.00
Ghazipur	8.45	35.22	56.30	89.33	11.93	30.40
Ballia	26.17	31.69	42.11	92.37	8.25	67.00
Gorakhpur	6.69	26.82	32.51	96.23	3.91	39.07
Deoria	1.04	49.41	49.52	77.36	29.25	49.62
Basti	7.60	31.38	61.00	99.98	-	30.80
Azamgarh	8.48	23.57	67.92	96.75	3.35	18.45
Naini Tal	84.94	13.36	1.67	76.68	30.39	26.16
Lucknow	60.00	11.45	28.53	81.42	22.81	58.96
Unnao	73.33	4.47	22.18	87.09	14.81	37.11
Rae Bareli	51.45	5.64	42.88	86.95	15.00	24.91
Sitapur	51.02	23.10	25.86	99.08	0.91	16.15
Hardoi	55.90	26.08	18.00	92.33	8.30	10.59
Kheri	27.22	60.91	11.84	96.63	3.47	31.49
Faizabad	19.51	27.03	53.44	88.15	13.43	35.57
Gonda	0.16	18.47	81.34	88.29	13.25	20.91
Bahraich	-	41.39	58.70	99.32	0.68	7.83
Sultanpur	17.53	11.53	70.91	97.33	2.74	31.59
Pratapgarh	27.19	0.21	72.57	92.96	7.56	34.02
Bara Banki	49.82	16.74	33.42	84.59	18.20	29.77
Uttar Pradesh	35.68	28.97	35.35	86.05	13.94	35.57

* Other sources include irrigation by wells, tanks, lakes and ponds etc.

irrigated area in each of the 48 districts for the year 1970-71. The corresponding details (area in hectares) relating to these appear in Appendix XII on which Fig.42 is based.

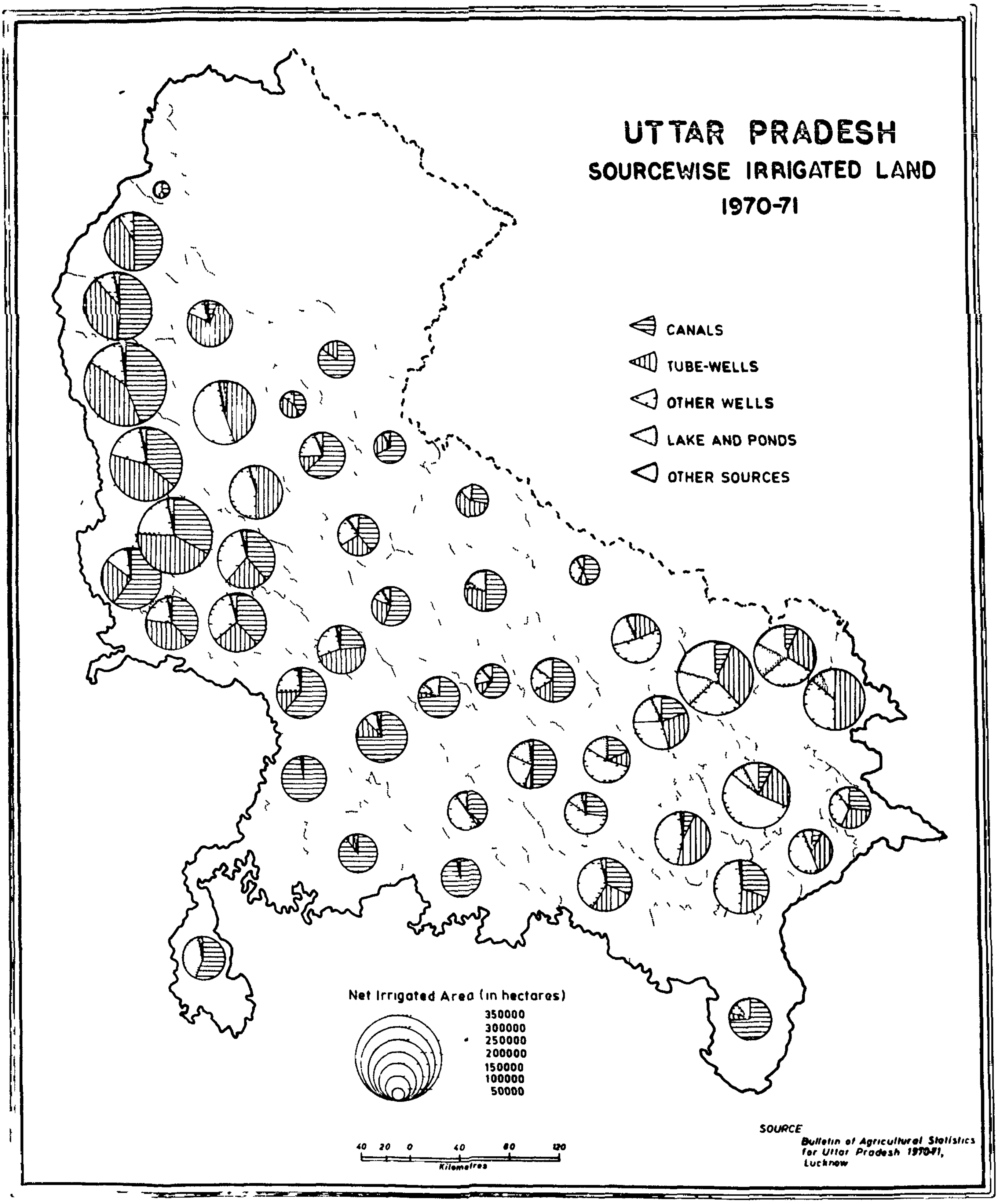

UTTAR PRADESH
SOURCEWISE IRRIGATED LAND
1970-71
CANALS
TUBE-WELLS
OTHER WELLS
LAKE AND PONDS
OTHER SOURCES
Net Irrigated Area (in hectares)
350000
300000
250000
200000
150000
100000
50000
40 20 0 40 80 120
Kilometres
SOURCE
Bulletin of Agricultural Statistics for Uttar Pradesh 1970-71, Lucknow

FIG 42

The overall intensity of irrigation on the basis of percentage share of gross irrigated area to the total cropped area can be judged from the Fig.43 in which all the fortyeight districts have been categorised under five broad groups with respect to their shares i.e., districts having share more than 55 per cent, a second group of districts between 45 and 55 per cent, the third group between 35 and 45 per cent, the fourth group of districts between 25 and 35 per cent and the fifth group of districts belong to very low percentage share, being less than 25 per cent.

It may be pointed out, that among all the districts belonging to first, second and third ranks i.e., of gross irrigated area more than 55 per cent between 45 and 55 per cent and the share between the range of 35 and 45 per cent respectively represent (with few exceptions) the whole of the Ganga-Yamuna Doab and few patches of districts elsewhere in the State. The remaining other districts fall either between the range of 25 and 35 per cent or less than 25 per cent (Fig.43).

(a) <u>Irrigation by Canals</u>

There looks an extensive network of canals which are serving vast agricultural lands in the State. There are a number of canal systems in different regions as well as in the districts of Uttar Pradesh. Canal irrigation possesses

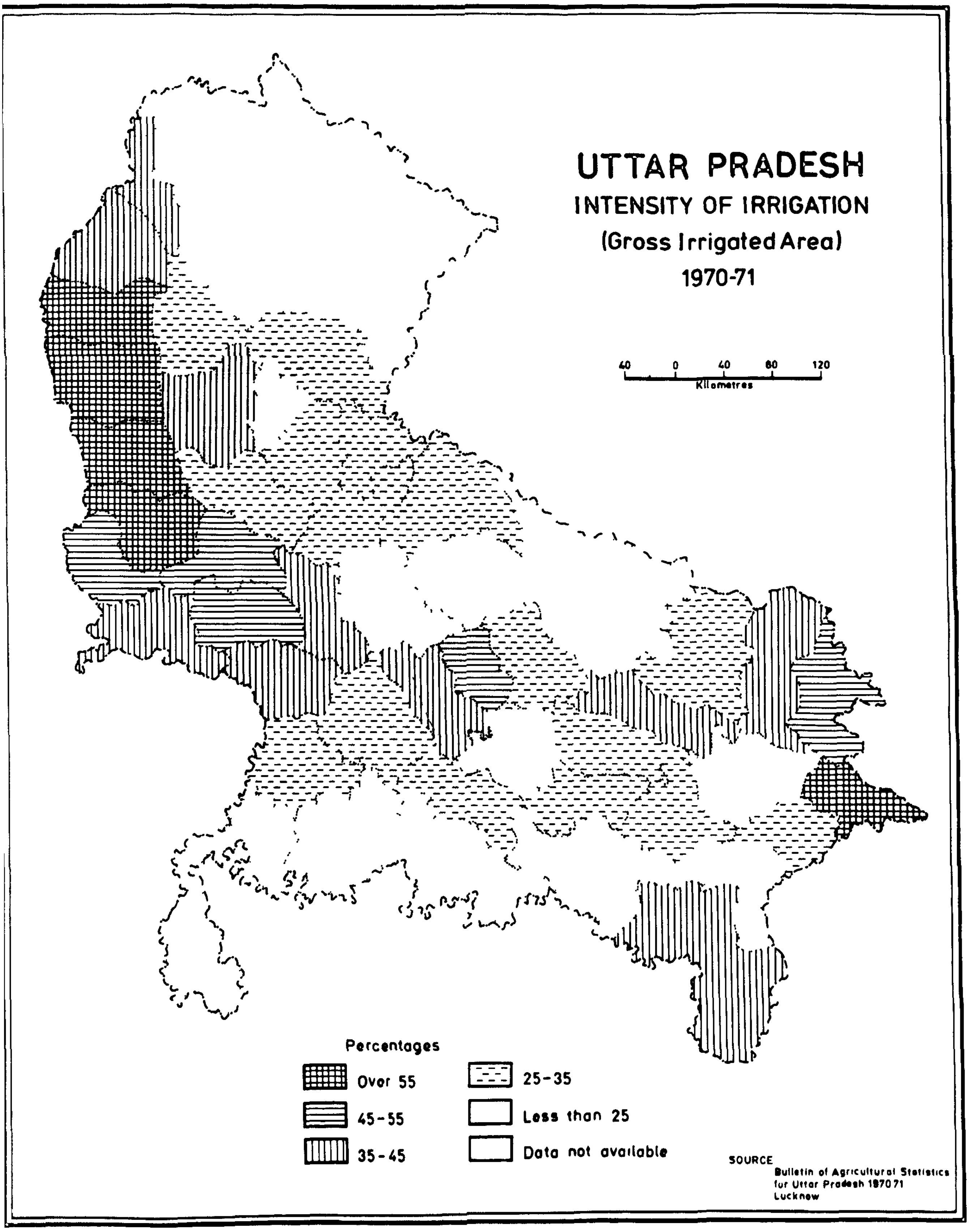

UTTAR PRADESH
INTENSITY OF IRRIGATION
(Gross Irrigated Area)
1970-71
40 0 40 80 120
Kilometres
Percentages
Over 55
45-55
35-45
25-35
Less than 25
Data not available
SOURCE
Bulletin of Agricultural Statistics
for Uttar Pradesh 1970 71
Lucknow

FIG. 43

a special significance among the other sources of irrigation in this State. This is due to its wide extent of coverage and low irrigation cost where it is needed for the crop production. The Fig.44 shows some of the major existing canal systems in the State. And the Table XXI shows their potentials with respect to number of districts are served by each of them, their culturable command area and an actual area irrigated, and proportion to irrigated area to the command area by each system during 1970-71.

It is evident from the above table, that Sarda canal is a biggest system in the State. Which serves as much as eighteen districts, viz., Pilihbit, Shahjahanpur, Hardoi, Khori, Sitapur, Lucknow, Unnao, Rae Bareli, Bara Banki, Pratapgarh, Sultanpur, Azamgarh, Jaunpur, Allahabad, Bareilly, Varanasi, Faizabad and Naini Tal of the State, with a total command area of 2.34 million hectares and an actual potential of irrigation of about 0.76 million hectares (32.74 per cent) to the command area (Appendix XIII). The upper-Ganga canal is the second largest system, which covers nine districts namely, Saharanpur, Muzaffarnagar, Meerut, Bulandshahr, Aligarh, Mathura, Agra, Etah and Mainpuri and all of them comprise parts of upper and middle Doab. Within this system the extent of command area accounted as of about 0.99 million hectares and the actual area received irrigation registered as about 0.73 million hectares (74 per cent). The third

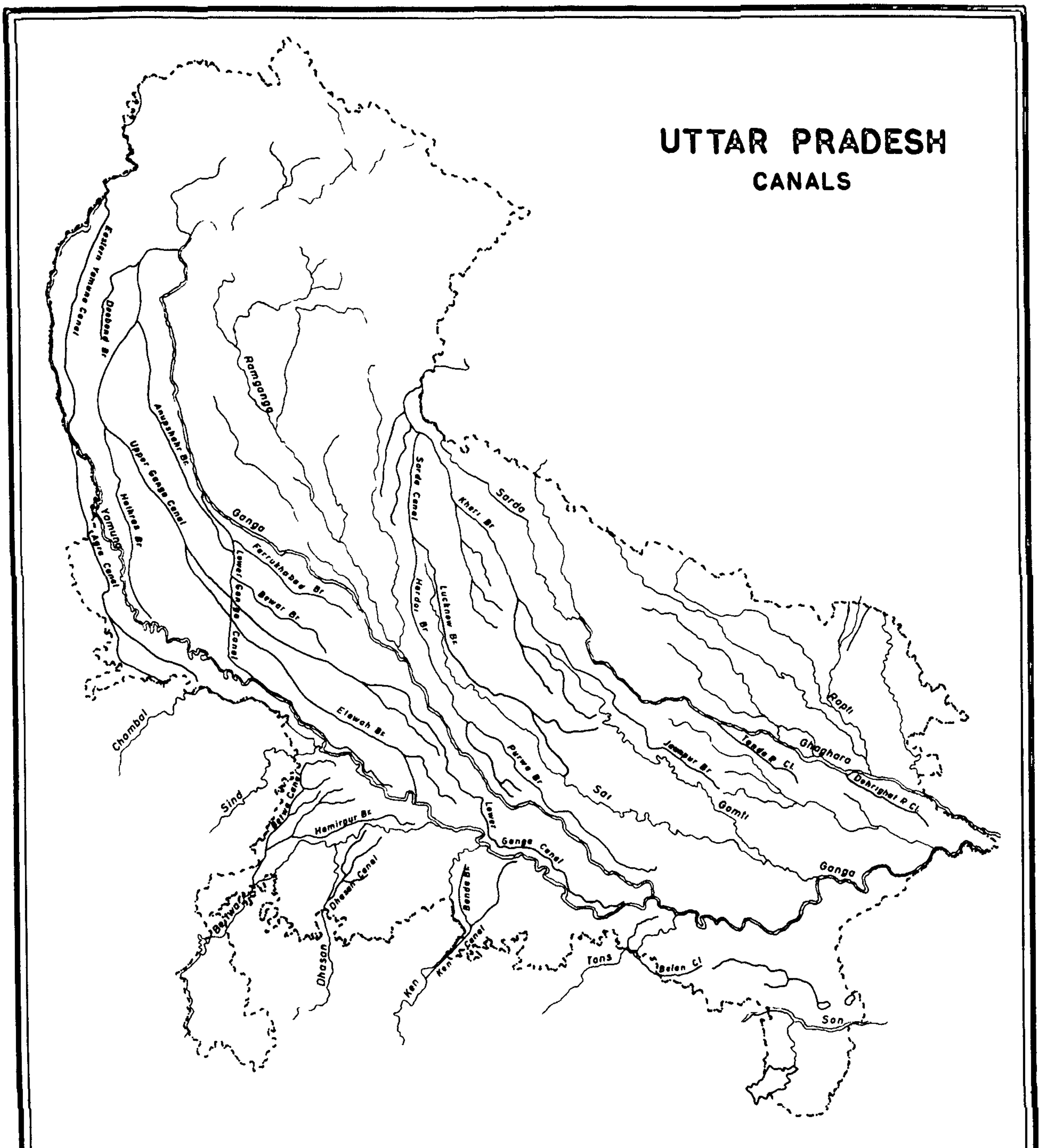

UTTAR PRADESH
CANALS
Eastern Yamuna Canal
Deoband Br.
Ramganga
Anupshahr Br.
Upper Ganga Canal
Mathura Br.
Yamuna
Agra Canal
Ganga
Farrukhabad Br.
Lower Ganga Canal
Bewar Br.
Sarda Canal
Kheri Br.
Sarda
Hardoi Br.
Lucknow Br.
Etawah Br.
Purwa Br.
Sai
Jaunpur Br.
Gomti
Rapti
Ghaghara
Dohrighat P. Cl.
Chambal
Sind
Hamirpur Br.
Lower Ganga Canal
Dhasan Canal
Banda Br.
Dhasan
Ken
Ken Canal
Tons
Belan Cl
Son
40 20 0 40 80 120
Kilometres
SOURCE
BASED UPON MAP OF IRRIGATION WORKS IN U P CHIEF ENGINEER IRRIGATION UTTAR PRADESH, LUCKNOW

FIG.3
FIG.44

TABLE XXI

Systemwise details of canal irrigation in U.P.-1970-71

(Area in hectares)

Source of water	Name of system	No.of distt. beni-fitted by the system	Agricul-tural command area	Actual irrigated area	Per cent to the comm-and area
1	2	3	4	5	6
Ganga River	Upper-Ganga Canal	9	9,92,182	7,33,556	73.93
Ganga River	Lower-Ganga Canal	8	9,67,456	4,88,508	50.49
Yamuna River	Eastern-Yamuna Canal	3	2,16,935	2,07,047	95.44
Sarda River	Sarda Canal	18	23,48,931	7,69,257	32.74
Yamuna River	Agra Canal	3	2,41,288	1,31,045	54.31
Ramgarh Tank	Ramganga Canal	2	30,840	5,329	17.28
Ramganga River	Afzalgarh Canal	1	10,000	2,888	28.88
Tumaria River	Tumaria Extension	2	37,087	8,389	22.62
-do-	Tumaria Canal	2	26,870	9,595	35.71
32 Rivers	Rohilkhand Canal	3	67,305	45,239	67.21
Ghaghara River	Ghaghara Canal	1	58,250	22,270	38.23
Mountain Streams	Dun Canal	1	15,804	14,104	89.24
Batwa River	Batwa Canal	3	3,70,716	1,90,104	51.34
Dhasan River	Dhasan Canal	1	96,044	42,112	43.85
15 Rivers	Rampur Canal	4	1,12,713	47,081	41.77
Rohin River	Rohin Canal	1	8,698	2,609	30.00
Tons River	Ramgarh Pump Canal	2	9,662	2,060	21.32
Ken River	Ken Canal	1	1,31,030	1,16,958	89.26
Tarai Rivers	Tarai Canals	4	43,768	37,682	86.09
Belan River	Belan Canal	2	93,748	28,208	30.09
-	Pili Canal	3	17,653	3,030	17.16
Mountain Streams	Hilly Canals	2	1,526	373	24.44
Karmnasa River	Karmnasa Canal	3	1,16,364	1,04,204	89.55
Greater Gandak River	Naraini Canal	2	36,904	11,722	31.76

(contd....)

TABLE XXI (Contd...)

1	2	3	4	5	6
Pahuj River	Pahuj & Garhmau Canal	1	1,536	4,764	31.47
Arjun River	Arjun Canal	1	48,279	1,279	26.34
Magaria Kulhariti River	Kaprai Canal	1	15,754	2,104	13.36
-	Govind Sagar (Lalitpur Canal)	1	40,416	8,519	21.07
-	Gursarai Canal	1	56,738	10,167	17.92
Lakheri River	Syawari Canal	1	7,279	2,591	35.60
Banda Channel	Barhawar Canal	1	7,160	2,670	37.29
Dhauri Canal	Dhauri Canal	1	3,417	1,127	32.98
Local Channel	Sukhra Canal	1	2,512	530	21.10
Local Channel	Dudhi Canal	1	3,551	1,675	47.17
Ghaghara Canal	Dohrighat Pump Canal	2	1,03,336	44,898	43.45
Tons River	Surhatal Pump Canal	2	11,524	4,184	36.31
Danda River	Danda Canal	1	3,698	1,310	35.42
Bhakeera Tank	Bhakeera Pump Canal	1	8,045	1,094	13.60
Banganga River	Banganga Canal	1	26,552	15,720	59.20
Tons River	Salona Tal Pump Canal	1	2,594	537	20.70
	Mountainous Canals	-	11,507	6,816	59.23
	Uttar Pradesh	-	42,95,761	31,45,948	73.23

Source: Uttar Pradesh Sinchai Vibhag Ka Varshik Pirtivedan 1970-71 (Hindi), Chief Engineer Irrigation, Uttar Pradesh, Lucknow.

major system which covers eight districts of the State is Lower-Ganga Canal. The districts usually benifitted under the system are namely, Aligarh, Etah, Mainpuri, Farrukhabad, Etawah, Fatehpur, Kanpur and Allahabad, which comprise parts of middle and lower Doab. The total commanded area under this system for the above districts comes as about 0.96 million hectares of which about 0.48 million hectares (50.49 per cent) brought under irrigation.

Apart from the above three major systems, the other systems cover although the small pockets of the districts, but all of them have their own significance and owe to be worthmentioned. Among others the Eastern-Yamuna canal covers the three districts of upper Doab, viz., Saharanpur, Muzaffarnagar and Meerut. In them this system commands about 0.21 million hectares of agricultural land with an irrigation potentials of 0.20 million hectares (95.44 per cent). This system has recorded a highest potentiality of irrigation. The Agra canal commands about 0.24 million hectares of agricultural land in three districts of Meerut, Mathura and Agra of Doab region to irrigate about 0.13 million hectares (54.31 per cent). The Ramganga canal commands the districts of Bijnor and Moradabad to irrigate 5,399 hectares (17.27 per cent) out of 30,840 hectares as commanded area. The Afzalgarh canal serves only Bijnor district by commanding about 10,000 hectares and to irrigate 2,888 hectares (34.62

per cent). Both the Tumaria Extension and Tumaria canal serve the districts of Naini Tal and Moradabad to irrigate 37,087 and 26,870 hectares respectively. The Rohilkhand canal is formed by supplementing itself by the waters of 32 rivers and commands the districts of Bareilly, Naini Tal and Pilibhit. The gross commanded area by these systems is 67,305 hectares of which 45,239 hectares (67.21 per cent) received irrigation during the corresponding year. The Ghaghara canal serves only the district of Faizabad, where it commands 58,250 hectares and irrigates actually 22,270 hectares (38.23 per cent) of the command area. The Dun canal commands 15,804 hectares of land Dehra Dun district and irrigates here 14,104 hectares (89.24 per cent).

In the Bundelkhand region Betwa canal commands about 0.37 million hectares of land in three districts of Jhansi, Jalaun and Hamirpur while irrigating about 0.19 million hectares (51.33 per cent). The Dhasan canal commands only Hamirpur district with an agricultural land of 96,044 hectares and irrigates an area of 42,112 hectares (22.80 per cent). The Rampur canal supplements itself by the waters of 15 rivers of the Rohilkhand region to command the districts of Bareilly, Moradabad, Naini Tal and Rampur with a coverage of about 0.11 million hectares and with the actual potentialities to irrigate about 47 thousand hectares (41.77 per cent).

The Rohin canal commands the Gorakhpur district and irrigates here 2,609 hectares (30 per cent) out of 8,698 hectares. The Ramgarh Pump canal in the eastern region commands the districts of Gorakhpur and Ghazipur with an area of 9,662 hectares of agricultural lands and irrigated during the corresponding year about 2,000 hectares (21.32 per cent) of the command area. The Ken canal irrigated about 0.11 million hectares (89.26 per cent) out of 0.13 million hectares in the district of Banda of Bundelkhand region. The Tarai canal serves the parts of Naini Tal, Moradabad, Rampur and Pilibhit districts, where it commands 43,768 hectares of agricultural land with a potentiality to irrigate about 37,500 hectares (86.09 per cent) of the command area. The Belan canal has a potentiality to irrigate 27,722 and 486 hectares in the districts of Allahabad and Mirzapur respectively. The Hilly canal feeds itself by the several other mountain rivers to command an area of about 1,526 hectares in Bijnor and Naini Tal districts, and irrigates about 373 hectares (24.44 per cent) in both of them.

The Karmnasa canal commands an area of about 0.11 million hectares in the three districts of eastern region, viz., Varanasi, Ghazipur, and Mirzapur with the actual irrigated area of about 0.10 million hectares (89.55 per cent) in them. The Narainy canal covers the lands in the northeastern districts of Gorakhpur and Deoria about 36,900 hectares and to irrigate actually about 11,700 hectares (31.76 per cent).

Apart from these, the Dohrighat Pump canal and the Surhatal Pump canal both command the agricultural lands in the districts of Ballia and Azamgarh, area being about 0.10 million hectares and about 11,500 hectares respectively with an actual irrigation potentiality of about 45,000 hectares (43.44 per cent) and 4,200 hectares (36.31 per cent) by each system. The other systems of canal irrigation in the State are known as local, therefore, their coverage with respect to irrigation is restricted within the premises of the district concerned.

(i) <u>Existing Canal Systems in the Districts</u>

Further, it has been attempted to trace out the respective position of each district with regard to the existing canal systems. Appendix XIII shows the number of districts under each system and existing systems in each of them, the agricultural command area, and the actual irrigated area by each system.

Among the districts of Uttar Pradesh, Dehra Dun receives water from Dun canal, where it irrigated an area of about 15,250 hectares. Agricultural lands in the district of Saharanpur is commanded by two systems namely, Upper-Ganga

Canal and Eastern-Yamuna Canal with a total irrigated area of about 0.14 million hectares by both the systems. The share of each system being about 50,000 and 80,000 hectares respectively. The district of Muzaffarnagar is also benifitted by both the above systems and here total irrigated area accounts about 0.18 million hectares of which, about 0.11 million hectares receive irrigation by Upper-Ganga Canal and the remaining about 63,700 hectares of land is irrigated by Eastern-Yamuna Canal. The agricultural lands in Meerut district are also benifitted by the same systems which Saharanpur and Muzaffarnagar posses. The total quantum of irrigated land here comes as about 0.35 million hectares of which about 0.17 million hectares irrigated by Upper-Ganga Canal and the remaining area of about 64,000 hectares by Eastern-Yamuna Canal, and a very tinny portion of land about 60 hectares received waters from Agra canal. The districts of Bulandshahr and Aligarh both are commanded by single Upper-Ganga Canal system, by which about 0.14 and 0.13 million hectares of land brought under the irrigation respectively, during the corresponding year. The Mathura and Agra districts are surved by Upper-Ganga Canal and Agra Canal, and both the system irrigated lands there about 0.13 million and 65,000 hectares respectively. Both, Etah and Mainpuri districts possess irrigation facilities of Upper-Ganga Canal and Lower-Ganga Canal systems. The area brought under irrigation by both the systems in each of them recorded as about 91,000 and 92,000 hectares respectively. The lands in Bareilly district are commanded by the Sarda, Rohilkhand and Rampur canals with an irrigated area of about 0.10 million hectares in aggregate. In the Bijnor district the agricultural lands are being irrigated by four systems, viz., Bijnor canal, Afzalgarh canal, Ramganga Pump canal and Pili canal and the area in aggregate by these systems recorded about 16,500 hectares (38.64 per cent) out of the 43,000 hectares of total command area.

In Moradabad district, there are six systems which irrigate lands and the total quantum of irrigated land recorded about 20,000 hectares out of the total command area of about 80,000 hectares (Appendix VI). The Sarda canal is the single source of canal irrigation in Shahjahanpur district, where it irrigates about 58,000 hectares of agricultural lands. There are three main sources of canal irrigation in Pilibhit district namely, Sarda canal, Tarai canal and Rohilkhand canal, they altogether irrigate about 62,000 hectares. In Rampur district, the Rohilkhand, Rampur and Tarai canals are the major sources of canal irrigation and by them the area brought under irrigation accounted about 47,000 hectares in aggregate.

Three districts of the Ganga-Yamuna Doab, viz., Etawah, Farrukhabad and Kanpur are commanded by the Lower-Ganga canal and the quantum of irrigated land by it recorded about 0.10 million hectares in districts of Etawah, 44,000 hectares and 1.1 million hectares in Farrukhabad and Kanpur respectively. In Allahabad district three systems namely, Lower-Ganga, Sarda and Belan canal irrigated altogether 66,513 hectares (32.54 per cent) out of the entire command area of about 0.20 million hectares, in the corresponding year.

Among the Bundelkhand districts, Jhansi is being served by six systems, viz., Betwa, Pahuj and Garhmau, Rampur (Saprar), Govind Sagar (Lalitpur canal), Gunsarai, Syavari and Barhawar canals, and an actual area brought under irrigation by them in aggregate accounted about 63,000 hectares (28.83 per cent) out of the command area of about 0.22 million hectares. The Betwa canal constitutes the only source of canal irrigation in Jalaun district, where it commands about 0.29 million hectares and irrigates about 0.15 million hectares (54.02 per cent). In Hamirpur district, Betwa, Dhasan, Arjun and Karai canals altogether irrigate about 62,000 hectares (34.40 per cent) out of the total command area of about 0.18 million hectares. In Banda district, Ken canal is the single source to irrigate about 0.11 million hectares.

In the Varanasi district, the Ghaghara and Sarda canals constitute the main source of canal irrigation. During the corresponding year both of them irrigated about 94,000 hectares. In Mirzapur district the agricultural lands receive waters from Dhori, Karmnasa, Sukhra and Duddhi canal systems, they cover to irrigate about 81,000 hectares here. The Jaunpur district has the facilities of canal irrigation only of the Sarda canal, which irrigates about 17,800 hectares of agricultural land. Both the Karmnasa and Ramgarh Pump canals irrigate 7,684 hectares in Ghazipur district. In Ballia district, Dohrighat and Surhatal Pump canals cover to irrigate about 36,900 hectares (42.84 per cent) out of the total command area of about 86,000 hectares. Six canal irrigation systems serve the district of Gorakhpur, they are namely, Rohin, Danda, Kuwano, Ramgarh and Bhira (Pump) canals, and Narayani canal with an actual irrigated area of about 18,000 hectares. The district of Deoria is served by Narayani canal by irrigating about 1,400 hectares. In Basti district, five systems serve the agricultural lands namely, Banganga, Kuwano and Bhakira (Pump), Basti (Pump) and Zamindari canals. The area covered by them for irrigation recorded about 30,000 hectares (44.85 per cent) out of about 66,000 hectares as commanded area. In the district of Azamgarh, the main sources of canal irrigation are the Sarda, Dohright, Tanda, Surhatal, Ratoi and Pakri and Salonatal (Pump) canals, by them an actual irrigated area recorded about 21,700 hectares.[1] In the Naini Tal district as many as eight systems exist to command an area of about 24,400 hectares. The agricultural lands in Lucknow district are served by the Sarda canal to irrigate about 49,000 hectares. The Sarda canal with its vast extent also serves the districts of Unnao, Rae Bareli, Sitapur, Hardoi and Kheri. By and large this is the only source of canal irrigation in the above six districts. Under the Sarda system the area under irrigation in each district accounted as about 99,000 hectares in Unnao, 78,550 hectares in Rae Bareli, 48,500 hectares in Sitapur and the Hardoi and Kheri shared waters on about 79,300 and 18,000 hectares respectively. The remaining three districts come under the coverage of Sarda system are namely, Sultanpur, Pratapgarh and Bara Banki, which show the figures of irrigated land as: Sultanpur 35,645 hectares, Pratapgarh and Bara Banki about 40,000 and 75,000 hectares respectively. In Faizabad district the Sarda canal irrigate a small portion of 620 hectares. In this district the Ghaghara canal constitutes a major source of canal irrigation to irrigate about 22,300 hectares and second to Ghaghara are the Tanda canal and Jahangirabad Branch, which irrigate about 21,650 hectares of agricultural land.

(b) Irrigation by Tube-Wells

Tube-well irrigation though of recent origin in India, but is of due importance in areas like Indo-Gangetic plains, which cover parts of the State of Punjab, Uttar Pradesh, Bihar, and Bengal where sub-soil water sources are in abundance for taping them for agricultural purposes. The importance of tube-well irrigation over canals lies because it can be constructed right in the centre of the places where waters are needed for the crop growth. The flow from the pump out-let to different fields by gravity is such over a short distance that there is no need to construct an extensive system of distributories.

The State of Uttar Pradesh has been the pioneer in the programme of 'State Tube-Wells'. As early as in 1931, after the completion of first stage of the Ganga canal and the hydro-electric grid schemes with the increase in the output of hydel power to 18,900 kw. by 1936, the prospects for starting the tube-well programme became brighter. In this State a scheme known as 'State Tube-Well Project' for 1,656 wells from 1934-35 to 1942-43 was prepared and completed in the early forties. Another project for additional 600 tube-wells was taken up at the instance of the Government of India under the programme 'Grow More Food Compaign' between 1943-44 and 1949-50. The total number of tube-wells installed in the State by the end of March 1946 were 1,847 which provided irrigation to 12.5 per cent of the total area irrigated in the State. During the period 1946-47 to 1950-51 another 456 tube-wells were constructed, bringing the total number to 2,305 tube-wells and irrigated area upto 14 per cent. Fig.45 shows the intensity of area under tube-well irrigation.

Table XXII shows figures relating to number of State tube-wells in operation, total area irrigated by them

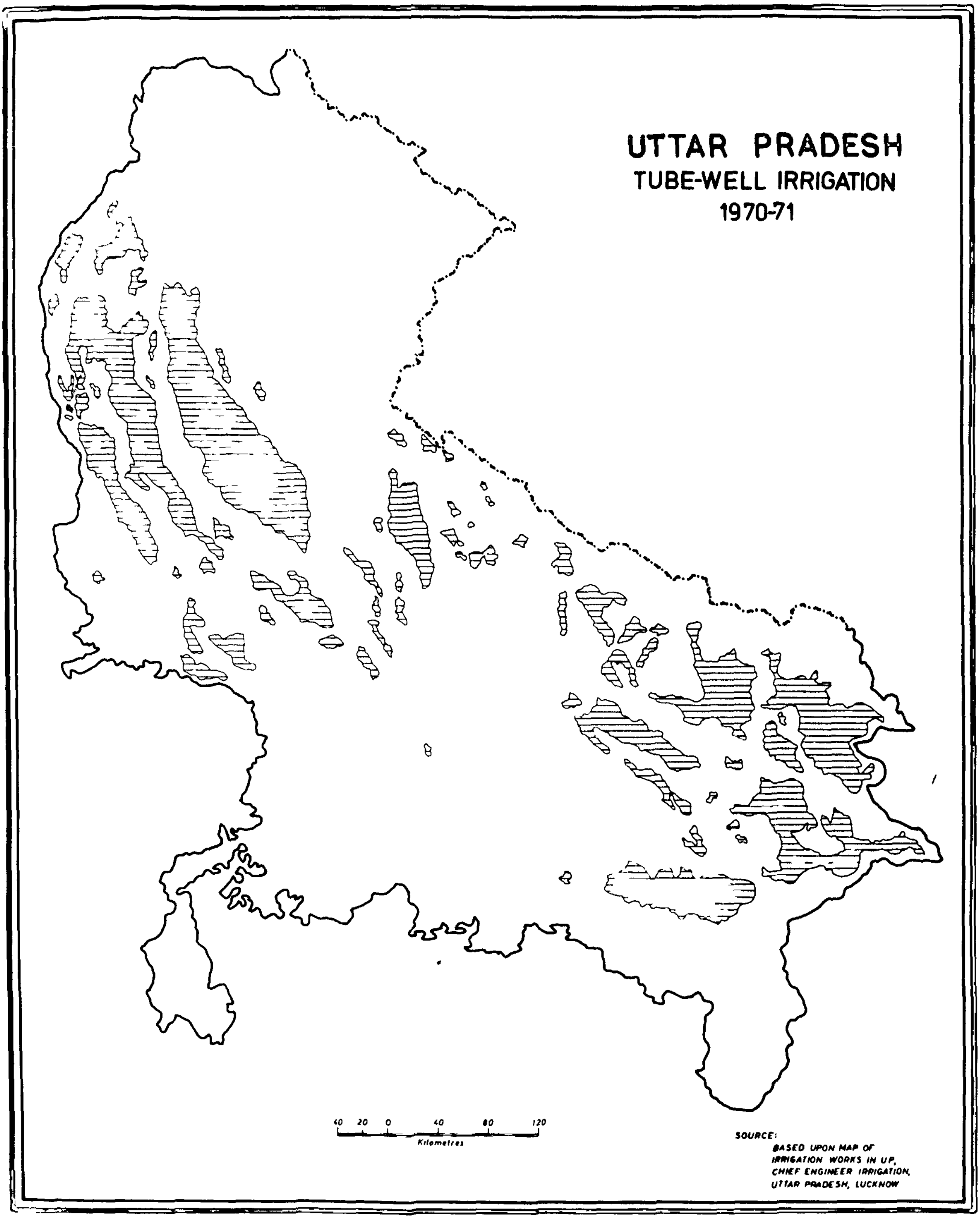

UTTAR PRADESH
TUBE-WELL IRRIGATION
1970-71
40 20 0 40 80 120
Kilometres
SOURCE:
BASED UPON MAP OF
IRRIGATION WORKS IN UP,
CHIEF ENGINEER IRRIGATION,
UTTAR PRADESH, LUCKNOW

FIG. 45

TABLE XXII

Districtwise details of irrigation by tube-wells in U.P.-1970-71

Name of district	No.of tube-wells in operation	Total area irrigated (in hectares)	Average area irrigated per tube-well (in hectares)	Total hours run of tube-wells	Average hours run per tube-well
1	2	3	4	5	6
Dehra Dun	12	2,949	328	22,062	2,451
Saharanpur	298	1,10,782	395	9,18,588	3,266
Muzaffarnagar	366	1,08,827	307	10,84,558	3,064
Meerut	690	1,81,933	279	18,91,160	2,903
Bulandshahr	630	1,31,191	214	14,19,223	2,314
Aligarh	507	1,24,242	253	10,91,441	2,229
Mathura	11	1,460	156	21,929	2,371
Agra	157	26,874	184	3,47,509	2,383
Mainpuri	188	34,434	193	4,04,224	2,264
Etah	227	49,285	238	4,70,502	2,273
Bareilly	176	30,284	177	2,82,780	1,657
Bijnor	426	1,38,822	172	7,73,862	1,849
Budaun	598	1,02,762	186	11,91,867	2,154
Moradabad	702	1,62,445	235	19,44,991	2,817
Shahjahanpur	117	26,311	209	2,34,485	1,868
Pilibhit	14	1,083	77	7,078	505
Rampur	136	27,468	201	2,64,652	2,069
Farrukhabad	271	46,634	193	5,20,788	2,147
Etawah	33	6,540	199	79,180	2,408
Kanpur	25	3,988	183	52,966	2,427
Fatehpur	1	88	88	1,671	1,671
Allahabad	320	73,853	266	7,61,756	2,747
Jhansi	-	-	-	-	-
Jalaun	-	-	-	-	-
Hamirpur	-	-	-	-	-
Banda	-	-	-	-	-

(contd.....)

TABLE XXII (Contd....)

1	2	3	4	5	6
Varanasi	578	1,24,791	229	16,91,584	3,123
Mirzapur	104	19,155	193	2,76,453	2,802
Jaunpur	276	50,262	186	6,43,307	2,390
Ghazipur	340	75,872	239	8,84,630	2,799
Ballia	217	45,230	216	4,76,690	2,286
Gorakhpur	284	55,619	202	5,36,718	1,952
Deoria	450	90,028	201	7,69,725	1,726
Basti	343	65,134	192	5,24,841	1,545
Azamgarh	293	63,088	226	5,65,522	2,053
Naini Tal	34	1,714	123	21,459	1,532
Lucknow	39	7,922	221	81,929	2,293
Unnao	-	-	-	-	-
Rae Bareli	-	-	-	-	-
Sitapur	113	18,064	161	1,81,007	1,624
Hardoi	93	14,856	170	1,23,397	1,425
Kheri	241	37,630	166	3,70,185	1,633
Faizabad	332	77,343	235	7,05,379	2,152
Gonda	197	39,221	198	2,51,463	1,274
Bahraich	114	19,669	181	1,31,234	1,151
Sultanpur	171	27,826	183	2,56,131	1,699
Pratapgarh	1	129	129	2,940	2,940
Bara Banki	48	7,583	163	75,413	1,624
Uttar Pradesh	10,173	21,66,552	223	2,23,57,279	2,305

Source: Office records of the Chief Engineer Irrigation, Uttar Pradesh, Lucknow.

hours run of tube-wells and average hours run per tube-well during 1970-71. There were 10,173 tube-wells in operation in Uttar Pradesh during the corresponding year. They irrigated altogether about 2.16 million hectares of agricultural land, with an average of 223 hectares of land per tube-well. All of them were energised to run upto 22.35 million hours, with an average figure of 2,300 hours per tube-well in a year. Among the other districts of the State Moradabad, Meerut and Bulandshahr were the leading districts which possessed the figures of 702, 690 and 630 tube-wells in each of them, with a total capacity to brought about 0.16, 0.18 and 0.13 million hectares respectively for irrigation. An average figures of irrigated area per tube-well come as 235, 279 and 214 hectares and average run per tube-well as 2,800, 2,900 and 2,300 hours for the above districts. Next to these is the district of Budaun in which tube-well irrigation constitutes the major source because it lies apart from the range of canal irrigation. The total irrigated area accounted here about 0.10 million hectares with an average figure of 186 hectares per tube-well and an average run of 2,154 hours per tube-well. The districts of Aligarh comprising the Doab region and Varanasi from the southeastern part of the State show comparably higher figures with respect to number of tube-wells in operation being 507 and 578 respectively. Total irrigated area accounted more or less about 0.12 million hectares in each of them, with an average figures of 253 and 229 hectares of irrigated land per tube-well. The figures of average run per tube-well computed as 2,230 and 3,120 hours respectively.

Among the districts possessing number of tube-wells less than the figures of 500 are: Saharanpur 298, Muzaffarnagar 366, Allahabad 320, Farrukhabad 271, and the remaining other districts of Doab region possess number of tube-wells below the figures of 200. In the districts of Saharanpur and Muzaffarnagar the State tube-wells irrigated more than 0.10 million hectares with an average irrigated per tube-well as 395 and 307 hectares respectively. The districts of Allahabad and Farrukhabad recorded total potentialities of irrigated area of about 74,000 and 46,000 hectares, and the average figures of irrigated land per tube-well computed as 266 hectares for Allahabad and 193 hectares for Farrukhabad, with an average figures of run hours per tube-well respectively.

Among the Trans-Ghaghara districts, Deoria registered 450 tube-well, Basti 343 and Gorakhpur 284 during the corresponding year. The total capacity of irrigated area computed for Deoria as 9,000, Basti 65,000 and Gorakhpur 55,000 hectares, with an average figures of 201, 192 and 202 hectares of irrigated area and the figures of average run per tube-well come as 1,726, 1,545 and 1,952 hours respectively.

Among the eastern districts of Ghazipur, Faizabad, Azamgarh, Jaunpur and Ballia the number of tube-wells in operation recorded for: Ghazipur 340, Faizabad 332, Azamgarh 293, Jaunpur 276 and Ballia 217, and the area brought under irrigation by them accounted about 76,000 hectares in Ghazipur (with an average of 239 hectares per tube-well), Faizabad 77,000 hectares (235 hectares per tube-well) and in the remaining three districts the irrigated area was about 63,000, 50,000 and 45,000 hectares and the average figures of irrigated land per tube-well were 226, 186 and 216 hectares respectively.

Apart from the above districts, in other districts the figures relating to number of State tube-wells are less as compared to other parts of the State, and the potentiality of irrigation too accounts considerably low. Among them six districts namely, Jhansi, Jalaun, Hamirpur and Banda of Bundelkhand region and two Unnao and Rae Bareli do not possess facilities of State tube-well irrigation. In them the farmers either depend upon timely rainfall or utilize waters of canals and wells etc. to irrigate their lands.

(c) <u>Irrigation by Other Sources</u>

As indicated earlier that the irrigation by other sources constitutes mainly by other wells, tanks and ponds, and other means. In the State where canal and tube-well irrigation show inadequacy to irrigate the agricultural land to the required extent the other sources supplement waters. In three districts of Gonda, Pratapgarh and Sultanpur more than 70 per cent of agricultural land receive irrigation by other sources. Next to these in seven districts of Ghazipur, Bahraich, Faizabad, Basti, Fatehpur and Moradabad the range being 67.92 per cent. An another group of districts the figures for other sources of irrigation ranges between 40 and 50 per cent (Table XX).

In the other six districts of Etah, Mainpuri, Bara Banki, Gorakhpur, Shahjahanpur and Farrukhabad the intensity of other sources of irrigation being between the range of 30 and 40 per cent. With the increase in the intensity of canal and tube-well irrigation, the irrigation by other sources lessen between the range of 20 and 30 per cent in the districts of Lucknow, Sitapur, Etawah, Bareilly, Bulandshahr, Aligarh, Mirzapur, Agra and Unnao, and between the range of 10 and 20 per cent in a group of another eight districts namely, Bijnor, Hardoi, Meerut, Rampur, Mathura, Saharanpur, Kanpur and Kheri. In the remaining six districts the figures of relative share of these sources range less than 10 per cent.

B. Food Crops Area Under Irrigation

As this study is based on considering only food crops grown in the State it is therefore, needful to assess also the cropwise area irrigated in the State as well as in each of the district of which we are concerned. Table XXIII shows irrigated area under each crop, and its per cent to the cropped area for three different points of time i.e., 1950-51, 1960-61 and 1970-71 in the State as a whole.

It is evident from the Table XXIII that during 1970-71 about 7.85 million hectares of land under food crops received irrigation which accounted 38.31 per cent of the total cropped area of the State. Among the individual crops potato, wheat, sugarcane, barley and pulses recorded priority in comparison to other crops in the State. The percentage share under each of them stands as potato 97.73, wheat 71.37, sugarcane 67.08, barley 55.66 and pulses 53.82 per cent to the cropped area of them.

It is also noticeable from the table, that during the last two decennial years the increase of irrigated area is registered as of about 0.30 million hectares (0.62 per cent per annum) in between 1950-51 and 1960-61, and during 1960-61 to 1970-71 as of about 2.70 million hectares (4.32 per cent per annum). Evidently the growth of irrigated area is much higher between the periods 1960-61 and 1970-71. Among the individual crops namely rice, maize, wheat, barley and gram

TABLE XXIII

Cropwise area under irrigation in U.P. - A trend of progress
(Area in hectares)

Food crops	1950-51		1960-61		1970-71	
	Irrigated area	Per cent to cropped area	Irrigated area	Per cent to cropped area	Irrigated area	Per cent to cropped area
Rice	4,09,029	10.61	5,01,792	12.48	7,44,800	16.86
Jowar	15,000	1.59	11,699	1.30	7,367	1.00
Bajra	2,542	0.24	3,677	0.33	4,769	0.42
Maize	35,738	4.29	68,430	6.56	2,50,797	16.75
Wheat	16,27,167	49.08	17,79,664	47.45	39,87,792	71.37
Barley	9,00,872	46.26	8,39,488	47.80	7,36,418	55.66
Gram	4,02,371	16.49	3,69,101	14.46	4,32,855	20.84
Sugarcane	6,93,078	68.41	8,73,981	65.81	9,02,231	67.08
Potato	77,461	94.46	1,00,732	94.14	1,51,794	97.93
Arhar	2,272	0.35	1,476	0.22	1,227	0.21
Pulses	6,43,726	51.17	5,73,657	51.86	5,66,745	53.82
Oilseeds	27,129	10.51	21,975	5.50	67,911	11.09
Total	48,36,385	27.43	51,45,672	27.19	78,54,706	38.31

accounted a regular increase during both the successive periods i.e., 1950-51 to 1960-61 and 1960-61 to 1970-71 with few exceptions in which a particular crop like wheat has shown a negative increase with respect to total cropped area during 1960-61 (Table XXIII).

Further, it has been attempted to compute the share of food crops area brought under irrigation to the respective crops (in aggregate) in each of the fortyeight districts of the State during 1970-71. Table XXIV shows the total food crops area irrigated and its share to the cropped area in each district on which Fig.46 is based. The districtwise details of food crops area under irrigation during the corresponding year are produced in Appendix XIV. The highest percentage of food crops irrigated area is associated with five districts of Doab, Muzaffarnagar, Meerut, Bulandshahr, Aligarh and Mathura, and one district Jaunpur of eastern region where the figures range more than 55.50 per cent. This group of districts accounts about an area of 1.93 million hectares of food crops irrigated. Between the range of 45.50 and 55.50 per cent are four districts of Doab namely, Saharanpur, Etah, Mainpuri and Etawah, and three eastern districts, viz., Varanasi, Azamgarh and Faizabad, accounting an irrigated area of food crops about 1.45 million hectares. The third rank comprises the districts of Dehra Dun, Bijnor, Naini Tal, Farrukhabad, Agra, Fatehpur first three being from northern part and latter three of Doab, and three viz., Gorakhpur, Deoria and Basti of Trans-Ghaghara tract, Ghazipur and Ballia eastern most districts, and among the central districts of Rae Bareli, Sultanpur and Pratapgarh having food crops area between the range of 35.50 and 45.50 per cent. These fourteen districts of the State accounted about 1.90 million hectares. Among the remaining twentyone districts

TABLE XXIV

Districtwise food crops area under irrigation in U.P.-1970-71

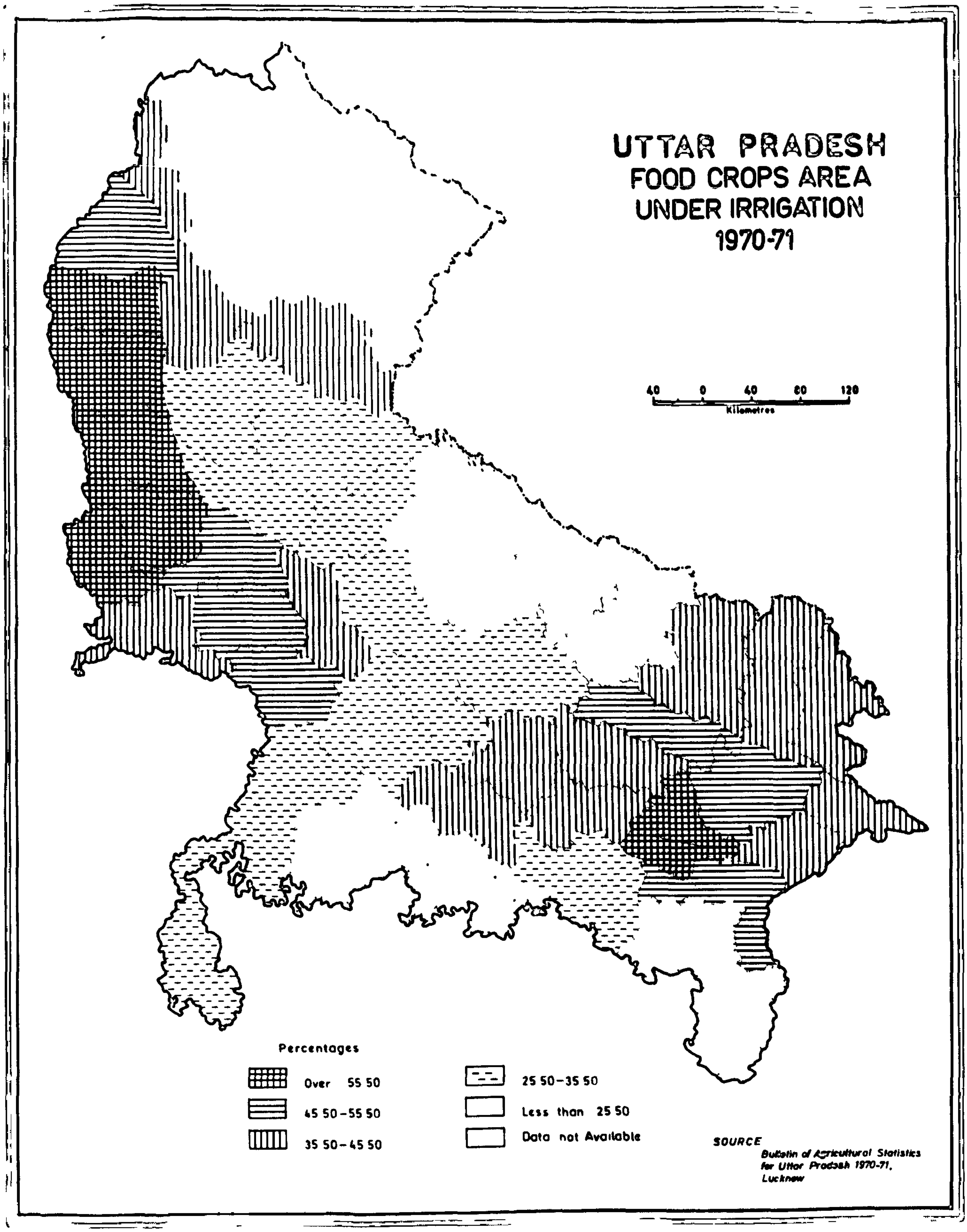
Name of district	Irrigated area (in hectares)	Per cent to cropped area
1	2	3
Dehra Dun	25,263	40.32
Saharanpur	2,39,272	53.05
Muzaffarnagar	2,96,994	78.98
Meerut	4,59,885	81.63
Bulandshahr	3,57,194	69.95
Aligarh	3,60,756	66.68
Mathura	2,11,929	58.01
Agra	1,66,904	40.96
Mainpuri	2,06,580	54.87
Etah	2,09,500	49.79
Bareilly	1,06,951	26.91
Bijnor	1,33,416	36.15
Budaun	1,71,289	34.60
Moradabad	2,63,793	45.76
Shahjahanpur	1,29,932	33.49
Pilibhit	85,801	32.69
Rampur	68,912	27.74
Farrukhabad	1,49,619	40.58
Etawah	1,73,078	46.37
Kanpur	1,67,215	35.27
Fatehpur	1,24,972	36.61
Allahabad	1,86,592	32.15
Jhansi	1,20,015	25.20
Jalaun	1,31,557	35.13
Hamirpur	87,285	18.08
Banda	30,744	5.40
Varanasi	2,00,972	50.85
Mirzapur	86,189	23.01

(contd.....)

TABLE XXIV (Contd....)

1	2	3
Jaunpur	2,47,233	67.93
Ghazipur	1,18,824	37.43
Ballia	1,03,793	37.45
Gorakhpur	2,37,691	40.57
Deoria	2,17,257	40.46
Basti	3,01,831	42.69
Azamgarh	2,43,988	46.80
Naini Tal	94,049	36.33
Lucknow	65,579	36.47
Unnao	1,34,983	35.31
Rae Bareli	1,43,996	40.53
Sitapur	1,00,259	20.81
Hardoi	1,32,574	26.07
Kheri	67,073	12.80
Faizabad	1,84,543	47,54
Gonda	1,47,121	22.25
Bahraich	55,016	9.54
Sultanpur	1,24,267	35.79
Pratapgarh	1,01,090	36.79
Bara Banki	1,22,106	31.68
Uttar Pradesh	78,54,706	38.31

the whole of the Rohilkhand region except the district of Bijnor possessed the share of food crops area under irrigation between the range of 25.50 and 35.50 per cent, and the four districts namely Hardoi, Unnao, Lucknow and Bara Banki



UTTAR PRADESH
FOOD CROPS AREA
UNDER IRRIGATION
1970-71
40 0 40 80 120
Kilometres
Percentages
Over 55 50
45 50-55 50
35 50-45 50
25 50-35 50
Less than 25 50
Data not Available
SOURCE
Bulletin of Agricultural Statistics for Uttar Pradesh 1970-71, Lucknow

FIG 46

including Allahabad and Kanpur of Doab region, and two districts of Jhansi and Jalaun too were categorised in the above range and accounted about 1.71 million hectares of food crops irrigated area. And the seven districts possessing very low share in food crops irrigation e.g., less than 25.50 per cent to the cropped area were namely, Kheri, Sitapur, Gonda, Bahraich, Banda, Hamirpur and Mirzapur to account only about 0.48 million hectares.

CHAPTER IX

RESOURCE USE IN THE STATE AGRICULTURE

This chapter has been devoted to ascertain the role of some of the technological and institutional aspects involved in the State agriculture and their trends of progress in the subsequent years. Districtwise variation analysis of these aspects has been assessed by accounting their gross distribution in each of the forty-eight districts as well as their quantum of distribution in relation to cropped land i.e., the spatial distribution in the concerned district during the year 1970-71. Prior to this year, the required details on these aspects for each district could not be available. This because of, that a new phase under the development planning in State's agriculture came with the introduction of green revolution during 1966-67 and is continuing today.

A. HIGH YIELDING VARIETIES PROGRAMME

With the inception of intensive cultivation programmes in early sixties the farmers had an unprecedent opportunity to bring a real break-through in agricultural productions in different parts of the State, and thereafter, the introduction of 'High Yielding Varieties Programme' lead the farmers to show awareness of its recognition. Resulting thereby, an abrupt replacement of areas under traditional varieties to new ones. Table XXV shows a trend of progress with respect to area planted under HYV with the advent of green revolution in the State from 1966-67 to 1970-71.

TABLE XXV

Area planted under High-Yielding Varieties Programme in U.P.- A trend of progress

(Area in hectares)

Name of crop	1966-67	1967-68	1968-69	1969-70	1970-71
Rice	45,089	1,53,220	8,73,076	13,80,059	15,20,583
Jowar	817	3,290	9,872	7,755	1,19,777
Bajra	781	31,631	11,396	25,928	1,59,541
Maize	15,312	61,250	4,30,297	6,14,908	6,48,692
Wheat	4,21,590	18,43,166	29,12,486	32,85,443	31,80,744
Barley	-	-	-	-	2,29,751
Gram	-	-	-	-	1,11,154
Peas	-	-	-	-	1,72,595
Total	4,83,589	20,92,557	42,37,127	53,14,093	61,95,867

Source: Directorate of Agriculture, Uttar Pradesh, Lucknow.

To begin with the year 1966-67 the crops under HYV programme introduced were namely, rice, jowar, bajra, maize and wheat, which covered altogether an area of about 0.48 million hectares. Among them rice and wheat ranked first and second respectively. In 1967-68 total area under these crops rose upto 2.09 million hectares about five times more as compared to the preceding year. Out of this, wheat only occupied about 1.84 million hectares (88.03 per cent). Rice placed at second rank, and the area under it rose three times and was recorded about 0.15 million hectares as compared to the previous year. Maize occupied a place next to rice and covered an area of about 61,000 hectares. Bajra was sown over an area of 32,000 hectares. During 1968-69 total area under HYV programme got doubled as compared to 1967-68 to cover about 4.23 million hectares. Wheat being the leading crop was sown on over an area of about 2.91 million hectares, and rice and maize covered an area of about 0.87 and 0.43 million hectares respectively. Bajra did not occupy any significant place and the area under it decreased from about 32,000 to 11,000 hectares as compared to the preceding year.

An additional area of about 1.07 million hectares further brought under HYV programme during 1969-70. In which wheat covered about 3.30 million hectares with an additional increase of about 0.37 million hectares as compared to 1968-69. Rice indicates a further increase of about 0.50 million hectares within a span of one year i.e., from 1968-69 to 1969-70. Maize and bajra further show a increase of an area about 1,84,000 and 14,000 hectares in 1969-70 respectively as compared to the preceding year. During 1970-71, this programme was further extended to cover three more crops, viz., barley, gram and peas with the addition of these crops, the area under wheat decreased at least to about 0.10 million hectares compared to the previous year. And under rice, the area shows a further increase of about 0.14 million hectares being about 1.38 million hectares in 1970-71. Maize shows a slight increase of about 34,000 hectares being about 0.61 million hectares in 1969-70 and about 0.65 million hectares during 1970-71. Area under bajra shows an abrupt shift during 1970-71 being about 0.16 million hectares, whereas during 1969-70 it covered only 25,000 hectares.

The figures of area under jowar also show an encouraging response given to this crop. An areal strength under HYV programme to this crop shifted from 8,000 to 1,20,000 hectares during the subsequent years i.e., 1969-70 and 1970-71. Among the other three crops which included in the programme in 1970-71 (the details of them are) as: barley occupied about 0.23 million hectares, peas was given second importance to cover an area of about 0.17 million hectares and about 0.11 million hectares of cropped land allotted to gram.

The initiation of HYV programme particularly to cereals has shown a satisfactory achievements upto the mark. Therefore, the performance of this programme seems to be very fast during the first three years since its inception and during last two years i.e., 1969-70 and 1970-71 the due responses reached upto a level of satisfaction (Table XXV). However, the objectives of modernising the agriculture in the State are underway and these have shown fruitful results in order to maximise the returns from land in various parts of the State.

(a) <u>Districtwise Area Planted Under HYV Programme</u>

Since the begining of high-yielding varieties programme upto 1970-71 a number of seed varieties which developed at various agricultural research institutes relating to major food crops were released by the State Agricultural Department.[1] Table XXVI shows districtwise details of area covered by each crop, viz., rice, jowar, bajra, maize, wheat, barley and gram under high-yielding variety of seeds (in aggregate) during 1970-71, and their corresponding details e.g., cropwise area in each district is produced in Appendix XV. And their percentages to the actual food crops area (in aggregate) brought under cultivation to the total cropped area are computed on which Fig.47 is based.

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1. The following varieties of seed are generally recommanded for different agro-climatic regions of the State: <u>Rice</u> - I.R.8, I.R.49, Jaya Padma and Jaichung Native 1; <u>Jowar</u> - C.S.H.1, C.S.H.2, Mauranipur and B.T.22; <u>Bajra</u> - H.B.1, H.B.4, Manpuri and S 530; <u>Wheat</u> - Kalyan Sona, Sonelika, Sarbati, Sonara, S 331 and White Larma; <u>Barley</u> - K 18, K 24, Jyoti and Ambar, and <u>Gram</u> - T 1, T2, T3 and K4.

TABLE XXVI

Districtwise area planted under High-Yielding Varieties Programme in U.P.- 1970-71

(Area in hectares)

Name of district	Area	Percentage
1	2	3
Dehra Dun	15,983	30.23
Saharanpur	1,23,894	36.19
Muzaffarnagar	1,37,274	55.55
Meerut	2,44,404	59.84
Bulandshahr	2,18,462	48.43
Aligarh	2,18,801	42.88
Mathura	1,41,246	42.56
Agra	1,04,718	29.89
Mainpuri	1,57,023	45.89
Etah	1,55,306	41.22
Bareilly	1,02,835	32.74
Bijnor	76,838	29.51
Budaun	1,53,940	38.97
Moradabad	1,99,830	42.56
Shahjahanpur	1,01,997	32.49
Pilibhit	64,960	31.01
Rampur	78,812	37.04
Farrukhabad	1,40,836	46.41
Etawah	1,13,580	34.79
Kanpur	1,68,634	41.97
Fatehpur	68,780	22.55
Allahabad	1,25,751	24.12
Jhansi	93,381	21.51
Jalaun	70,962	21.44
Hamirpur	37,091	8.51
Banda	36,397	7.00

(contd......)

TABLE XXVI (Contd.....)

1	2	3
Varanasi	1,32,946	38.77
Mirzapur	48,375	15.22
Jaunpur	1,34,376	41.46
Ghazipur	82,461	30.89
Ballia	78,605	32.97
Gorakhpur	2,18,971	40.61
Deoria	1,98,852	44.61
Basti	3,20,122	48.44
Azamgarh	1,69,015	37.44
Naini Tal	82,058	42.85
Lucknow	69,351	45.26
Unnao	93,075	28.17
Rae Bareli	1,04,484	33.99
Sitapur	1,03,498	27.23
Hardoi	93,742	24.12
Kheri	84,401	22.48
Faizabad	1,85,935	53.45
Gonda	2,59,223	43.44
Bahraich	1,22,074	23.27
Sultanpur	1,20,896	38.79
Pratapgarh	73,628	31.37
Bara Banki	1,65,622	49.33
Uttar Pradesh	61,95,867	34.78

Note: Percentages refer to the total area under the crops concerned.

Source: Directorate of Agriculture, Uttar Pradesh, Lucknow.

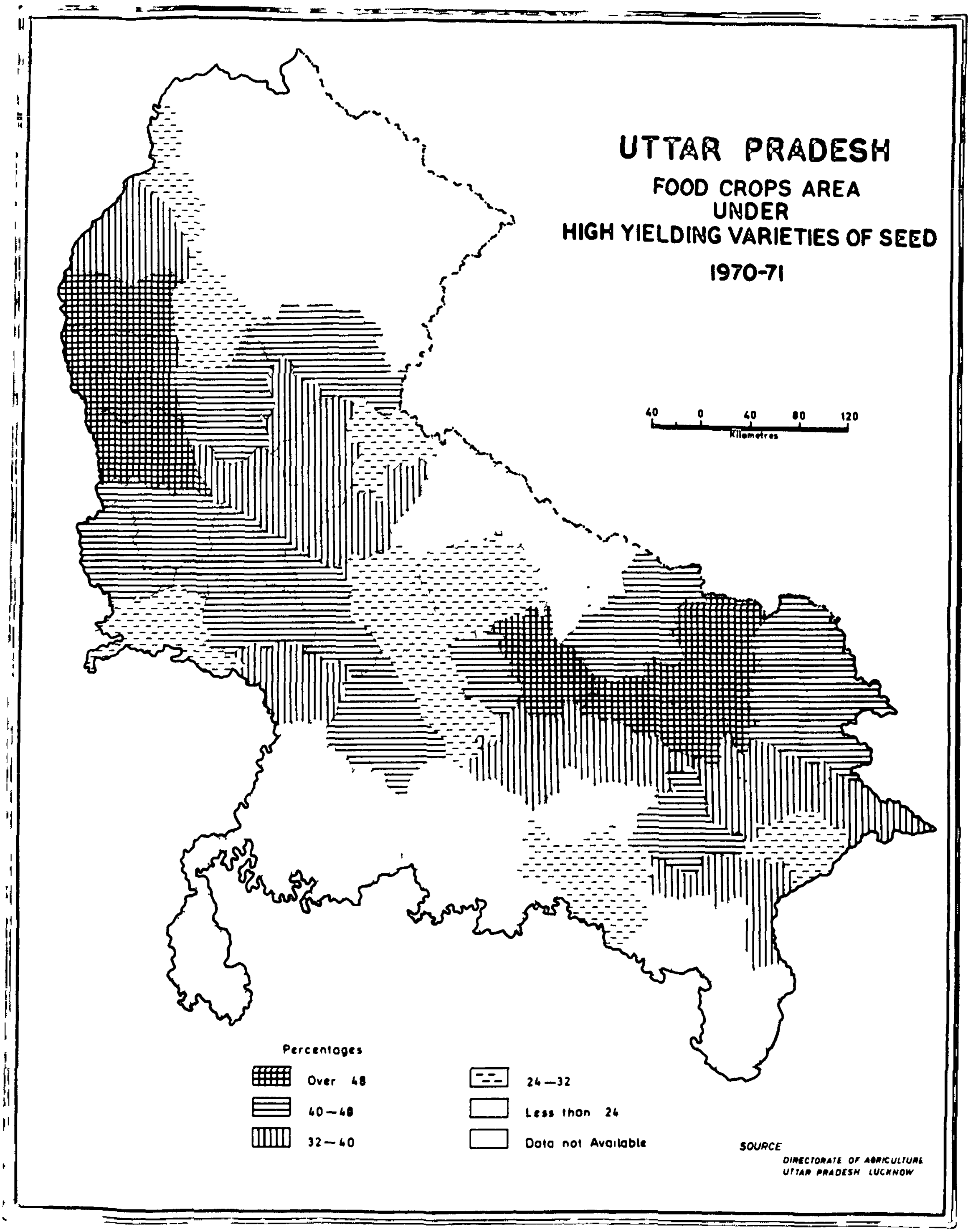
UTTAR PRADESH
FOOD CROPS AREA
UNDER
HIGH YIELDING VARIETIES OF SEED
1970-71
40 0 40 80 120
Kilometres
Percentages
Over 48
40—48
32—40
24—32
Less than 24
Data not Available
SOURCE
DIRECTORATE OF AGRICULTURE
UTTAR PRADESH LUCKNOW

FIG 47

The performance of crop plantation under this programme looks very appreciable in three districts of upper Doab namely, Muzaffarnagar, Meerut and Bulandshahr, and the three districts of Bara Banki, Faizabad. In Muzaffarnagar it covered about 0.13 million hectares (55.55 per cent). Meerut and Bulandshahr shared about 0.24 and 0.22 million hectares (59.84 and 48.43 per cent) respectively. Area under it in Bara Banki was recorded about 0.16 million hectares (49.33 per cent), and in Faizabad and Basti about 0.18 and 0.32 million hectares (53.45 and 48.44 per cent) respectively. Next to these a very appreciable gain is to be seen in other districts which covered an area between 40 and 48 per cent of the cropped area, among them six districts, viz., Aligarh, Mathura, Etah, Mainpuri, Farrukhabad and Kanpur comprise Doab region, three districts of Trans-Ghaghara tract namely, Gonda, Gorakhpur and Deoria, and Lucknow and Jaunpur representing central and eastern parts of the State. Among the Rohilkhand districts, only Moradabad falls within this category.

The actual area covered by Doab districts recorded for Aligarh and Mathura as about 0.29 and 0.14 million hectares (42.88 and 42.56 per cent), Etah and Mainpuri about 0.15 and 0.15 million hectares (41.22 and 45.89 per cent) respectively, and Farrukhabad and Kanpur recorded about 0.14 and 0.17 million hectares (46.41 and 41.97 per cent) respectively.

Among the Trans-Ghaghara districts Gonda covered about 0.26 million hectares (43.44 per cent), and in Gorakhpur and Deoria the area under the programme extended upto an area of about 0.22 and 0.20 million hectares (40.61 and 44.61 per cent) respectively, In Lucknow this programme commanded an area of about 69,000 hectares (45.26 per cent) and the figures for district Jaunpur as about 0.13 million hectares (41.46 per cent). Lastly the districts of Moradabad and Naini Tal exibit an area of about 2,00,000 and 82,000 hectares (42.56 and 42.85 per cent) respectively.

Among the districts which show a moderate gain, are namely, Saharanpur and Etawah, where an area of about 0.12 and 0.11 million hectares (36.19 and 34.79 per cent) put to this programme respectively. And out of seven, four districts of Rohilkhand region, viz., Rampur, Bareilly, Budaun and Shahjahanpur come under the range of between 32 and 40 per cent in respect to total cropped area. The share of Rampur recorded as about 78,000 hectares (37.04 per cent), Bareilly accounted about 0.10 million hectares (32.74 per cent), and in Budaun and Shahjahanpur about 0.15 and 0.10 million hectares (38.97 and 32.49 per cent) respectively allotted to this programme.

There are altogether nine districts scattered over the State, which show a low level of gain under HYV programme. They are namely, Dehra Dun, Bijnor, Pilibhit, Agra, Ghazipur, Allahabad and the remaining three districts Hardoi, Sitapur and Unnao from central region, where the percentage of area under food crops varieties ranges between 24 and 32 per cent. Apart from these, the remaining nine districts belong to the category which shows relatively no gain and the area under the programme ranges generally less than 24 per cent. The areas belonging to this category include the entire Bundelkhand tract and the districts of Mirzapur, Fatehpur, Pratapgarh, and Bahraich of the State. The poor response of this programme in these districts is associated with the fact, that most of them possess comparatively low levels of productivity and agricultural development is restricted due to a number of other factors.

(b) Targets and Achievements

During 1970-71 the State's Agricultural Department proposed to bring an area of about 4.19 million hectares in order to maximise the benifits of HYV programme in the State. The achievements surpassed the target by bringing an area of about 6.20 million hectares (148.00 per cent) under the programme in the State.

The districtwise achievements over target figures under the programme are well established in the districts of Shahjahanpur, Mathura, Muzaffarnagar, Bulandshahr, Meerut, Gorakhpur, Moradabad, Lucknow, Etah and Agra which attained

TABLE XXVII

Districtwise area planted under High-Yielding Varieties Programme in U.P.- Target and achievement- 1970-71

(Area in hectares)

Name of district	Target	Achievement	Percentage (3/2 x 100)
1	2	3	4
Dehra Dun	12,530	15,983	127.55
Saharanpur	84,451	1,23,894	146.70
Muzaffarnagar	74,273	1,37,274	184.82
Meerut	1,40,056	2,44,404	174.50
Bulandshahr	1,23,497	2,18,462	176.89
Aligarh	1,42,559	2,18,801	153.48
Mathura	70,217	1,41,246	201.15
Agra	65,128	1,04,718	160.78
Mainpuri	1,04,527	1,57,023	150.22
Etah	94,011	1,55,306	165.19
Bareilly	1,57,348	1,02,835	65.35
Bijnor	2,44,651	76,838	31.40
Budaun	88,338	1,53,940	174.26
Moradabad	1,19,595	1,99,830	167.08
Shahjahanpur	50,380	1,01,997	202.45
Pilibhit	49,085	64,960	132.34
Rampur	60,697	78,812	129.84
Farrukhabad	95,440	1,40,836	147.56
Etawah	73,954	1,13,580	153.58
Kanpur	1,24,008	1,68,634	135.98
Fatehpur	51,490	68,780	133.57
Allahabad	99,813	1,25,751	125.98
Jhansi	79,017	93,381	118.17
Jalaun	52,860	70,962	134.24
Hamirpur	51,505	37,091	72.01
Banda	49,813	36,397	73.06

(contd.....)

TABLE XXVII (Contd....)

1	2	3	4
Varanasi	1,04,255	1,32,946	127.52
Mirzapur	40,335	48,375	119.93
Jaunpur	90,901	1,34,376	147.82
Ghazipur	54,794	82,461	150.49
Ballia	54,657	78,605	143.81
Gorakhpur	1,30,167	2,18,971	168.22
Deoria	1,29,413	1,98,852	153.65
Basti	2,12,708	3,20,122	150.49
Azamgarh	2,25,285	1,69,015	75.02
Naini Tal	57,243	82,058	143.35
Lucknow	41,665	69,351	166.44
Unnao	61,793	93,075	150.62
Rae Bareli	65,789	1,04,484	158.81
Sitapur	69,266	1,03,498	149.42
Hardoi	64,273	93,742	145.83
Kheri	63,143	84,401	133.66
Faizabad	1,23,442	1,85,935	150.62
Gonda	1,82,480	2,59,223	142.05
Bahraich	95,565	1,22,074	127.73
Sultanpur	87,837	1,20,896	137.63
Pratapgarh	75,668	73,628	97.30
Bara Banki	1,13,654	1,65,622	145.72
Uttar Pradesh	41,89,861	61,95,867	147.82

Source: Office records Directorate of Agriculture, Uttar Pradesh, Lucknow.

more than 160.00 per cent area under the programme against the figures of target (Table XXVII). Next to these, where the achievement ranges between 150 and 160 per cent are the districts of Rae Bareli, Unnao and Faizabad. In the third category of achievenent the following districts recorded success within the range of 140 and 150 per cent namely, Sitapur, Jaunpur, Farrukhabad, Saharanpur, Hardoi, Bara Banki, Ballia, Naini Tal and Gonda. In comparison to other regions of the State the districts of Sultanpur, Kanpur, Jalaun, Fatehpur, Kheri and Pilibhit exhibit a slow and moderate success as their achievement ranged between 130 and 140 per cent. Among the remaining thirteen districts, seven, out of them may be grouped where achievement ranged between 100 and 130 per cent and the remaining six of them fall below 100 per cent, they are namoly, Pratapgarh, Azamgarh, Banda, Hamirpur, Bareilly and Bijnor.

Alongwith the spatial variations relating to the coverage of HYV programme the figures of target and achievement also reveal uneven levels of success in different parts of the State. Although the patterns of coverage and achievement of area under HYV programme are not uniform. However, some districts show the similar pattern specially in the Doab region and out of five, four districts of Trans-Ghaghara plains, viz., Basti, Gonda, Deoria and Gorakhpur (excluding Bahraich). And five districts lying south of the Yamuna river fall far below the average range in both the cases.

B. DISTRIBUTION AND CONSUMPTION LEVELS OF FERTILIZER

Fertilizers constitute an important component for increasing agricultural production and play a key role in intensive farming system. The importance of fertilizers in the phase of green revolution has been well appreciated by the cultivators, as well as all others concerned with agricultural production. The contribution of fertilizers in increasing agricultural production has been very well demonstrated in our country as well as in other countries of the world.

Page, stated that fertilizers use is essential for raising the agricultural productivity to the required level in order to supply the needed food and fibre in these words:[2]

> "It is however, not generally recognised that they (fertilizers) must play an all-important part, not merely as one of the alternative means to this end (increased food production), but they are indeed a key factor in practically all schemes for increased supplies the world over".

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2. Page, H.J., "Trends in Fertilizer Consumption in Relation to World Food Supply", Outlook on Agriculture, Vol.II, 1959, p.203.

A comparative study made for First and Second Five Year Plans period (1950-61) revealed that in India fertilizers contributed in increasing agricultural production to the extent of 45 per cent, while other factors like irrigation, improved seeds, double cropping and land reclamation measures contributed only 27 per cent, 13 per cent, 10 per cent and 5 per cent respectively. In a study prepared in U.S.A. it was found that fertilizers constituted the largest single factor in increasing total crop production there, and accounted for 50 per cent increase in yields.

A series of trails conducted by Food and Agriculture Organization of the United Nations in fourteen different countries in the world have established beyond any doubt that substantial increases in yield of crops can be obtained by the use of fertilizers, even if, no other technical factor is changed. Further, FAO's Freedom from Hunger Compaign Fertilizer Programme, shows a comparable results with the major food crops of twentythree developing countries in three regions of the world. A large number of trails and demonstrations laid down with different crops in farmers' fields over the period 1961-62 to 1964-65 indicate that small and marginal farmers applying their traditional methods can raise their yields by an average of over 50 per cent through the use of relatively low rates of fertilizer alone. Averaging all the results recorded, it may be estimated that the average economic return was over four times the cost of the fertilizers applied.[3]

(a) Importance of Soil Testing for Fertilizer Recommendations in Crop Production

In order to get maximum advantages from the application of fertilizers it becomes necessary that the fertility status of fields in respect to various major nutrients be determined before sowing a crop, so that, the required nutrients may be applied to the field through the use of fertilizers, manures or both. Increased use of fertilizers for replenishing soil nutrition for obtaining increased crop yield has gained momentum.

For achieving maximum economic gains from fertilizer use it is essential to determine the existing status of soil fertility so that, it could precisely be determined as to what quantities of different fertilizers need to be applied per unit area in relation to the requirements of the proposed cropping programme. With the expansion of area under high-yielding varieties a heavy consumer of soil nutrients if has become essential that the systematic soil testing programme should be carried out for

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3. FAO, FFHC Fertilizer Programme, Physical and Economic Survey of Trial and Demonstration Results 1961-62 - 1964-65, Rome, 1967.

evaluating nutritional deficiencies of the soil. In view of the above needs of the farmers the State Government in collaboration with the private educational institutions has established a chain of soil testing laboratories in Uttar Pradesh for facilitating soil analysis for diagnosing the level of nutrients and formulating suitable fertilizer recommendations and other soil management practices for specific problem of the fields.

Soil testing service in Uttar Pradesh was started in 1961 with the establishment of a Soil Testing Laboratory at Kanpur under the 'Expanded Soil Testing Scheme' of the Government of India as a unit of All India Soil Testing Programme under which twentyfour soil testing laboratories were started at different parts of the country with the help of United States Agency for International Development. During 1964-65 this service was extended to sixteen other existing laboratories. At present twentyfive government laboratories and an equal number of private educational institutions are participating in this project in Uttar Pradesh. Since the inception of soil testing work in the State a total number of 1,87,251 soil samples analysed upto 1970-71. Out of the total samples, 1,67,741 (89.58 per cent) samples analysed in government laboratories and the remaining 9,511 (10.42 per cent) samples at various educational institutions. And the recommendations were send to the cultivators for their use[4] Based on the soil testings a range of recommended doses of fertilizers (NPK)[5] kg. per hectare cropwise different physical regions are shown in Table XXVIII and Table XXIX subsequently shows the main manuring seasons recommended for different food crops in the State.

(b) Allocation of Fertilizers Through Different Agencies

During 1970-71 the fertilizers were distributed among the farmers through the following agencies:

(i) Agricultural Supply Organization,

(ii) Provincial Co-operative Federation,

(iii) Cane and other Agencies,

(iv) State Agro-Industrial Corporation, and

(v) Private Agencies.

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4. Fertilizer and Allied Statistics U.P., Department of Agriculture, Uttar Pradesh, Lucknow, 1972, pp.81-82.
5. Nitrogen (N), Phosphorus (P) and Potassium (K) are the important elements and are required in large quantitites by crops due to common deficiency in soils. Therefore, they in concentrated forms are applied to the soil to raise the fertility of land.

   Nitrogenous fertilizers include ammonium sulphat, ammonium nitrates, sodium nitrates, calcium nitrates, calcium cynamide and urea. Phosphatic fertilizers include superphosphate, and Potassium fertilizers include potassium sulphate and muriate.

TABLE XXVIII

Fertilizer recommendations for different crops in physical division of U.P.

(Dose in terms of NPK kg/hect

Physical division	Rice	Jowar	Bajra	Maize	Wheat	Barley	Gram	Sugar cane	Potato	Arhar	Pulses	Oilseed
1	2	3	4	5	6	7	8	9	10	11	12	13
I. Sub-Montane Tract	16-43	-	-	16-39	12-37	-	-	46-101	32-67	-	-	-
II. Gangetic Plain												
(a) Ganga-Yamuna Doab	17-42	15-36	15-36	16-45	18-42	18-42	8-36	46-139	40-77	-	16-51	-
(b) Ganga-Gomti and Gomti-Ghaghara Interfluve	16-47	14-37	14-37	13-44	16-39	16-39	8-34	46-91	51-22	-	5-25	-
(c) Trans-Ghaghara Districts	18-37	16-28	16-28	17-41	16-42	16-42	11-27	46-91	46-71	-	5-25	-
(d) Rohilkhand Districts	18-39	14-37	14-37	17-40	16-39	16-39	5-25	44-82	-	-	5-25	-
III. Trans-Yamuna Tract	16-42	14-37	14-37	-	15-39	15-39	5-25	-	43-77	-	8-36	-

Source: Fertilizer and Allied Statistics U.P., Department of Agriculture, Lucknow, 1972.

TABLE XXIX

Main manuring season for different crops in U.P.

Name of crop	Normal manuring period for		
		Top dressing	
	Basal dressing	First	Second
Rice			
(i) Early	June - July	July - Aug.	--
(ii) Late	July - Aug.	Sept.	--
Jowar	June - July	Aug.	--
Bajra	June - July	Aug.	--
Maize	June - July	Aug.	--
Wheat	Oct.	Dec. - Jan.	--
Barley	Oct. - Nov.	Nov. - Jan.	--
Gram	Oct.	--	--
Sugarcane	Oct.-Nov.-Feb.	May	Jan.
Potato	Sept.-Oct.-Feb.	Oct. - Dec.	Jan.
Pulses	--	--	--
Oilseeds			
(i) Groundnut	Jun.- July	--	--
(ii) Castor	July- Oct.	Sept.	--
(iii) Rape and mustard	Oct.- Nov.	Dec. - Jan.	--
(iv) Linseed	Oct.	Dec. - Jan.	--

Source: Fertilizer and Allied Statistics U.P., Department of Agriculture, Lucknow, 1972.

In order to assess the role of above agencies in distribution of fertilizers in the State Table XXX may be consulted which shows the distribution pattern of fertilizers (NPK) by each agency since 1963-64 to 1970-71.

It is clear from the Table XXX,that there is a gradual increase in the distribution of fertilizers except the year 1970-71. In which the ASO and Cane and other agencies distributed only 157 and 43 thousand tonnes respectively against the figures of 184 and 157 thousand tonnes during the previous year i.e., 1969-70 respectively. There is a abrupt shift from 77 tonnes during 1963-64 to 410 tonnes in 1970-71 with respect to total quantum of fertilizers distribution. It is well established fact that ASO is the leading agency for distribution of fertilizers to the farmers in the State.

Besides the total quantity of fertilizers distribution, it is also needful to consider nutrientwise distribution of fertilizers in the State. Accordingly, Table XXXI shows nutrientwise distribution of fertilizers i.e., NPK nutrient forms. It is evident from the table that, there is a positive increase since 1956-57 in the distribution of fertilizers. For instance, the nitrogen (N) given 20,000 tonnes in 1956-57 raised upto about 28,000 tonnes in 1960-61. This quantity further increased from

TABLE XXX

Agencywise distribution of fertilizers in U.P.- A trend of progress

(in tonnes)

Name of agency	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71
1	2	3	4	5	6	7	8	9
Agricultural Supply Organization	28,527	41,258	41,393	40,711	1,34,924	1,72,025	1,84,420	1,57,370
Provincial Co-operative Federation	29,588	32,826	32,984	28,806	43,076	92,752	1,10,552	1,21,680
Cane and other agencies	19,189	23,944	18,114	17,066	20,597	72,453	1,57,910	43,350
State Agro-Industrial Corporation	-	-	-	-	-	-	5,344	22,046
Private agencies	-	-	-	-	-	-	-	66,094
Total	77,305	98,028	92,491	86,583	1,98,597	3,37,230	4,58,226	4,10,550

Source: <u>Fertilizer and Allied Statistics U.P.</u>, <u>Department of Agriculture, Lucknow</u>, 1972.

TABLE XXXI

Nutrientwise distribution of fertilizers in U.P. - A trend of progress

(in tonnes)

Year	N_2	P_2O_5	K_2O	Total
1956-57	20,040	455	-	20,495
1960-61	28,447	2,276	-	30,723
1965-66	84,152	8,785	-	92,937
1970-71	2,91,425	74,507	44,608	4,10,540

Source: Fertilizer and Allied Statistics, U.P., Department of Agriculture, Lucknow, 1972.

84,000 tonnes to 2,91,000 tonnes between the period 1965-66 and 1970-71. The phosphatic (P) nutrient distributed only 455 tonnes during 1956-57 and in 1960-61 about 2,000 tonnes. This recorded a further increase from about 9,000 to about 74,500 tonnes in 1965-66 and 1970-71 respectively. In case of potassium (K), it shared about 44,500 tonnes in the total distribution of fertilizers during 1970-71. Out of the total distribution of 4,10,540 tonnes (NPK) during 1970-71, the ASO contributed 38.33 per cent PCF shared 29.63 per cent, cane and other agencies distributed 10.55 per cent, and both SAIC and private agencies contributed 5.37 per cent and 16.09 per cent respectively.

(c) <u>Districtwise Distribution of Fertilizer</u>

Districtwise total quantum of fertilizers given to the farmers by each agency during 1970-71 is produced in Appendix XVI. And Table XXXII is based on the Appendix XVI, in which the percentage share of each agency and in each district is shown for the corresponding year as regard to fertilizers distribution in the State. It is clear from the table that the highest ranking districts were Meerut and Muzaffarnagar from upper Doab where farmers given about 27,500 and 18,500 tonnes of fertilizers (NPK) respectively (Appendix XVI). Out of the total quantity in Meerut about 7,750 tonnes (28.24 per cent) distributed by ASO, about 8,500 tonnes (30.47 per cent) by PCF about 6,500 tonnes (23.51 per cent) through cane and other agencies about 700 tonnes (2.63 per cent) by SAIC and about 5,100 tonnes by private agencies. In district Muzaffarnagar ASO shared about 5,700 tonnes (30.58 per cent) out of total distribution of 18,638 tonnes, PCF distributed about 4,000 tonnes (22.17 per cent), cane and other agencies about 4,500 tonnes (23.81 per cent), and each SAIC and private agencies about 500 tonnes (2.73 per cent) and 3,860 tonnes (20.72 per cent) respectively.

Among the other higher ranking districts Deoria, Basti and Gorakhpur the fertilizers distribution recorded

TABLE XXXII

Districtwise distribution of fertilizers through different agencies in U.P. - 1970-71

(Figures in percentages)

Name of district	Agricultural Supply Organisation	Provincial Co-operative Federation	Cane and other agencies	State Agro-Industrial Corporation	Private agencies
1	2	3	4	5	6
Dehra Dun	29.17	37.07	16.74	14.54	2.51
Saharanpur	28.29	28.81	23.41	4.40	15.08
Muzaffarnagar	30.58	22.17	23.81	2.73	20.72
Meerut	28.24	30.67	23.51	2.63	18.59
Bulandshahr	44.72	29.70	3.50	10.79	11.94
Aligarh	65.41	18.79	-	11.34	4.48
Mathura	46.15	35.23	-	12.18	6.44
Agra	50.02	21.57	-	21.02	7.29
Mainpuri	49.28	29.56	-	14.29	6.85
Etah	46.95	26.93	-	13.09	13.03
Bareilly	30.63	31.17	11.54	3.19	23.47
Bijnor	31.91	38.44	22.87	2.63	7.48
Budaun	47.92	24.57	4.61	9.71	13.19
Moradabad	31.71	29.59	12.45	4.37	21.87
Shahjahanpur	50.66	28.02	5.07	4.46	10.24
Pilibhit	26.40	25.24	25.77	10.56	11.92
Rampur	30.12	31.89	7.77	8.67	21.55
Farrukhabad	25.34	25.70	-	8.66	33.43
Etawah	46.52	42.25	-	4.73	8.15
Kanpur	51.16	19.15	-	3.93	25.76
Fatehpur	38.99	21.68	-	6.03	22.87
Allahabad	53.34	39.11	-	5.66	2.02
Jhansi	79.36	13.17	-	3.74	3.74
Jalaun	56.70	35.95	-	3.65	1.00

(contd.....)

TABLE XXXII (Contd....)

1	2	3	4	5	6
Hamirpur	80.67	17.86	-	-	1.47
Banda	72.61	22.40	-	3.33	1.67
Varanasi	25.85	34.07	0.83	3.25	36.01
Mirzapur	34.84	49.08	-	6.20	9.87
Jaunpur	31.45	36.38	4.67	4.03	23.57
Ghazipur	44.16	33.97	-	4.13	17.74
Ballia	41.78	34.18	0.79	4.26	19.00
Gorakhpur	43.19	30.03	12.93	3.64	12.29
Deoria	28.46	31.14	25.91	4.56	9.64
Basti	39.53	33.54	14.06	2.45	10.49
Azamgarh	40.19	31.60	-	7.00	21.32
Naini Tal	7.13	28.50	19.82	9.90	34.65
Lucknow	28.31	24.40	1.18	3.42	42.69
Unnao	60.85	25.94	-	6.12	7.09
Rae Bareli	60.24	27.39	-	4.09	8.29
Sitapur	36.67	22.01	31.61	5.83	3.88
Hardoi	50.07	26.72	12.81	6.93	3.71
Kheri	22.70	15.17	49.08	7.17	5.88
Faizabad	38.41	36.42	6.06	3.09	23.78
Gonda	45.90	35.59	10.36	2.02	6.55
Bahraich	57.02	35.65	-	-	7.33
Sultanpur	46.97	39.74	-	1.30	11.98
Pratapgarh	48.43	36.62	-	13.93	14.11
Bara Banki	36.98	27.06	8.37	0.49	27.10
Uttar Pradesh	38.33	29.63	10.55	5.37	16.09

as: in Deoria the farmers received about 19,400 tonnes of fertilizers in the forms of 13,230 (N), 3,700 (P) and 2,500 tonnes (K). Here ASO supplied 5,500 tonnes (28.46 per cent), by PCF about 6,000 tonnes (31.14 per cent), by cane and other agencies 5,000 tonnes (25.91 per cent), by SAIC 883 tonnes (4.56 per cent) and by private agencies about 1,870 tonnes (9.64 per cent). In Basti and Gorakhpur distribution of fertilizers recorded about 19,400 tonnes and Gorakhpur 16,400 tonnes respectively. In each of them ASO contributed 7,650 tonnes (39.53 per cent) in Basti, 7,100 tonnes (43.19 per cent) in Gorakhpur, PCF distributed about 6,500 (33.54 per cent) and 5,000 (33.03 per cent) respectively, cane and other agencies allocated about 7,700 tonnes (14.06 per cent) and 2,125 tonnes (12.93 per cent) each in Basti and Gorakhpur. The SAIC and private agencies given 475 tonnes (2.45 per cent) and 2,000 tonnes (10.50 per cent) in Basti, and about 600 tonnes (3.64 per cent) and 2,000 tonnes (12.29 per cent) respectively in Gorakhpur.

There are two other districts namely, Saharanpur and Bulandshahr in which distribution exceeded more than 15,000 tonnes. In between ASO supplied about 4,400 tonnes (28.29 per cent) in Saharanpur, about 6,900 tonnes (44.72 per cent) in Bulandshahr. The contribution of PCF recorded about 4,400 tonnes (28.81 per cent) and 4,500 tonnes (29.70 per cent) in Saharanpur and Bulandshahr respectively. The farmers of Saharanpur received about 3,600 tonnes (23.41 per cent) from cane and other agencies and in Bulandshahr 533 tonnes (3.50 per cent), and in both of them SAIC given 670 tonnes (4.40 per cent) in Saharanpur and in Bulandshahr about 1,650 tonnes (10.80 per cent). The distribution through private agencies recorded in Saharanpur about 2,300 tonnes (15.08 per cent) and Bulandshahr 1,800 tonnes (11.95 per cent).

Besides these high ranking districts with regard to the total distribution of fertilizers, there are some other districts which fall in certain range of fertilizer distribution next to the highest rank. Among them are namely, Farrukhabad, Gonda, Faizabad, Moradabad, Bara Banki, Varanasi and Aligarh in which the distribution of NPK ranges between 1,000 and 1,500 tonnes. An average share of each agency comes in the distribution in these districts as: by ASO 38.51 per cent, PCF 29.44 per cent, cane and other agencies 5.44 per cent, SAIC 4.73 per cent and by private agencies as 21.88 per cent. The range between 7,500 and 10,000 tonnes of fertilizers distribution covered nine districts representing different parts of the State namely, Naini Tal, Bareilly, Bijnor, Azamgarh, Kanpur, Jaunpur, Rampur, Budaun and Allahabad. Among them, the average share of each agency in the fertilizers distribution comes as: by ASO 34.75 per cent, PCF 30.20 per cent, cane and other agencies 11.86 per cent, SAIC 6.08 per cent and by private agencies 17.11 per cent. There are altogether eleven such districts of the State, in which total distribution of fertilizers through all the agencies ranged between 5,000 and 7,500 tonnes. They are namely, Sultanpur, Etah, Mainpuri, Agra, Etawah, Shahjahanpur, Kheri, Bahraich, Pilibhit, Pratapgarh and Sitapur. In them, the average share of each agency recorded as: by ASO 42.78 per cent, PCF 28.35 per cent, cane and other agencies 10.14 per cent, SAIC 9.58 per cent and private agencies 9.15 per cent. In the remaining other districts, viz., Lucknow, Mathura, Ghazipur, Ballia, Fatehpur, Hardoi, Jalaun, Rae Bareli, Mirzapur, Jhansi, Banda, Dehra Dun and Hamirpur accounted total distribution of fertilizers from all the agencies within the range of less than 5,000 tonnes. This is because many of them belong to agriculturally less advanced and of low productivity areas. An average figures of percentage in distribution by each agency comes as: by ASO 49.03 per cent, PCF 28.16 per cent, cane and other agencies shared 7.88 per cent, SAIC 5.08 per cent and private agencies 9.85 per cent.

(d) Fertilizer Consumption Levels

Since we are concerned with the total quantum of fertilizers distribution, it is also needful to assess the consumption levels nutrientwise as well as in aggregate on per hectare of cropped land. This assessment will further help to investigate the farmer's awareness and of decisions in response to the adoption of package of practices in order to raise the quantum of returns per hectare.

Table XXXIII shows a trend of progress in the consumption of fertilizers (nutrientwise and total) at different points of time since 1956-57 on per hectare of cropped land. It is clear from the table, that there is a wider acceptance of consumption in the State during the corresponding years.

TABLE XXXIII

Consumption levels of fertilizers in U.P. - A trend of progress

(kg per hectare)

Year	N_2	P_2O_5	K_2O	Total
1956-57	0.94	0.02	-	0.96
1960-61	1.31	0.10	-	1.41
1965-66	3.81	0.40	-	4.21
1970-71	12.85	3.28	1.97	18.10

Source: Office records Directorate of Agriculture, Uttar Pradesh, Lucknow.

Although there are variations in the consumption levels of fertilizer in different districts of Uttar Pradesh, but some of them show a level of satisfaction. Table XXXIV shows the average range of consumption levels in each of the fortyeight districts of the State during 1970-71 on which Fig.48 is based. It is indicated by the map that there are four districts of upper Doab namely, Meerut, Muzaffarnagar, Saharanpur and Bulandshahr in which farmers are well aware about the importance of fertilizers application. In them, the levels of consumption per hectare are computed with an average figures for Meerut 39.03 kg, Muzaffarnagar 38.99 kg, Saharanpur 27.64 kg and Bulandshahr 26.44 kg. Here the nutrientwise consumption levels are in accordance with the recommended doses for the Doab region which they represent (Table XXVIII). There are some other patches of districts including Rampur, Farrukhabad, Faizabad, Bara Banki, Gorakhpur, and Deoria which show the levels of fertilizer consumption more than 25 kg per hectare. The nutrientwise doses (NPK) in these districts at an average come as: N 21.54 kg, P 5.22 kg and K 3.14 kg. Among other districts representing the Rohilkhand region namely, Bijnor, Moradabad, Bareilly and Pilibhit, one district Basti of Trans-Ghaghara tract, two districts of Jaunpur and Varanasi from eastern part and Lucknow from central part the consumption levels fall between the range of 20 and 25 kg

TABLE XXXIV

Districtwise fertilizer consumption levels in U.P.-
1970-71

(kg per hectare)

Name of district	N_2	P_2O_5	K_2O	Total
1	2	3	4	5
Dehra Dun	9.22	2.81	1.56	13.59
Saharanpur	19.42	5.45	2.77	27.64
Muzaffarnagar	28.65	6.77	3.59	38.99
Meerut	27.58	7.94	3.51	39.03
Bulandshahr	17.78	5.98	2.68	26.44
Aligarh	12.01	3.72	1.98	17.71
Mathura	8.34	2.34	1.14	11.82
Agra	9.48	2.67	1.73	13.88
Mainpuri	12.87	2.44	1.76	17.07
Etah	11.43	2.28	1.60	15.31
Bareilly	15.64	4.42	2.43	22.49
Bijnor	15.98	4.07	2.15	22.20
Budaun	11.51	2.20	1.32	15.03
Moradabad	15.76	2.80	1.49	20.05
Shahjahanpur	10.50	2.31	1.57	14.38
Pilibhit	15.43	2.96	1.78	20.17
Rampur	19.04	6.92	3.14	29.10
Farrukhabad	26.55	4.00	3.17	33.72
Etawah	12.12	2.27	1.13	15.52
Kanpur	10.22	2.43	1.49	14.14
Fatehpur	6.57	1.56	1.16	9.29
Allahabad	11.24	2.80	1.58	15.62
Jhansi	2.02	0.61	0.43	3.06
Jalaun	6.20	2.58	0.64	9.42
Hamirpur	1.35	0.41	0.19	1.95

(contd.....)

TABLE XXXIV (Contd....)

1	2	3	4	5
Banda	1.15	0.61	0.29	2.05
Varanasi	17.41	3.16	2.89	23.46
Mirzapur	4.44	1.58	1.19	7.21
Jaunpur	14.32	3.46	2.89	20.67
Ghazipur	8.86	2.87	2.04	13.77
Ballia	9.59	2.69	2.16	14.44
Gorakhpur	18.46	4.70	2.36	25.52
Deoria	21.88	6.07	4.09	30.04
Basti	17.71	4.56	2.59	24.86
Azamgarh	11.40	2.58	1.68	15.66
Naini Tal	6.29	1.75	0.87	8.91
Lucknow	18.68	4.73	1.52	24.93
Unnao	5.29	1.12	1.10	7.51
Rae Bareli	6.55	1.37	1.09	9.01
Sitapur	7.92	1.35	0.67	9.94
Hardoi	6.17	0.98	0.75	7.90
Kheri	7.33	1.86	0.98	10.17
Faizabad	22.72	5.66	4.26	32.64
Gonda	11.52	4.24	3.12	18.88
Bahraich	5.74	2.15	1.42	9.31
Sultanpur	11.74	3.59	2.61	17.94
Pratapgarh	11.00	3.67	2.62	17.29
Bara Banki	20.64	3.98	3.16	27.78
Uttar Pradesh	12.85	3.28	1.97	18.10

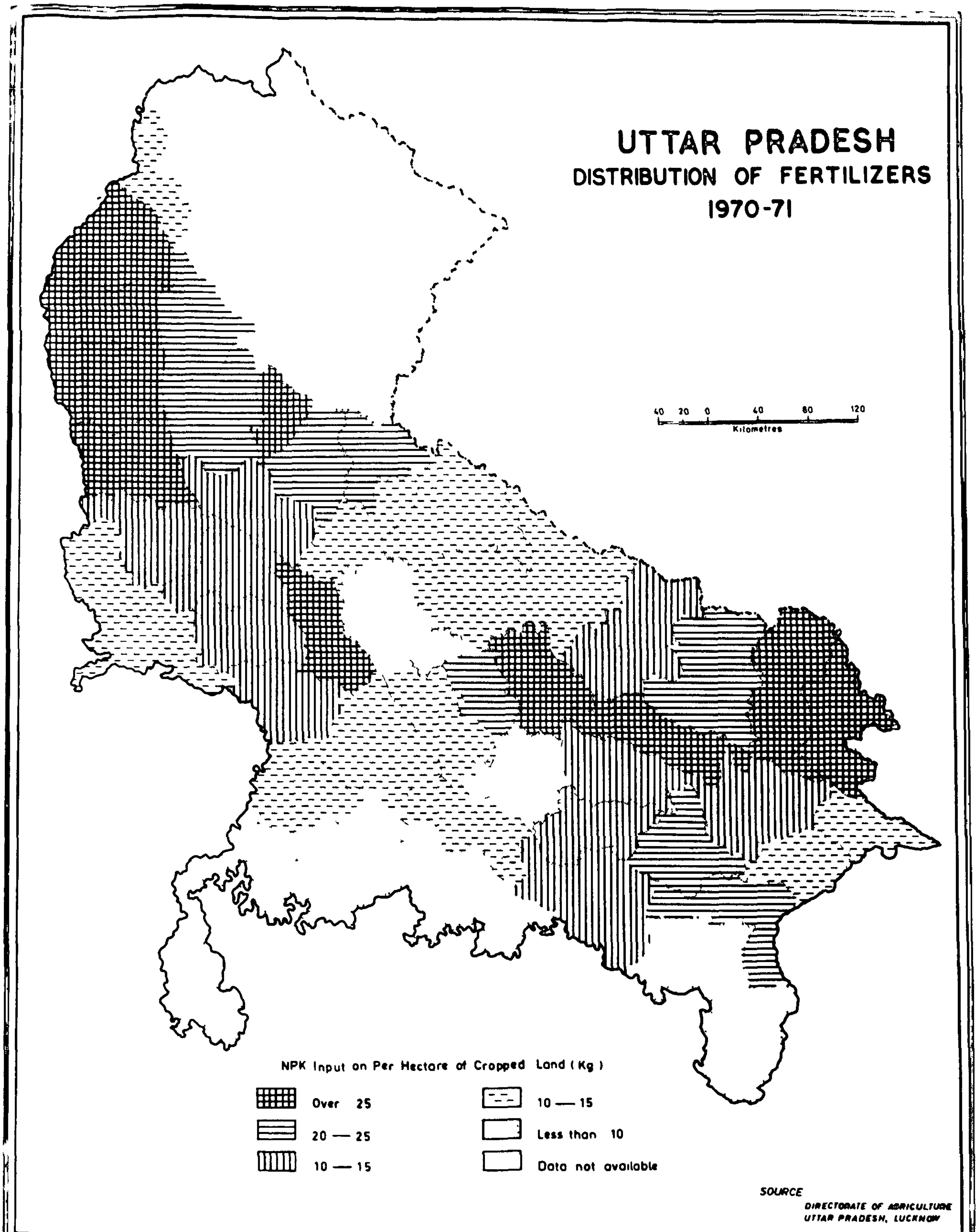
UTTAR PRADESH
DISTRIBUTION OF FERTILIZERS
1970-71
40 20 0 40 80 120
Kilometres
NPK Input on Per Hectare of Cropped Land (Kg)
Over 25
20 — 25
10 — 15
10 — 15
Less than 10
Data not available
SOURCE
DIRECTORATE OF AGRICULTURE
UTTAR PRADESH, LUCKNOW

FIG. 48

per hectare. An average consumption of nutrients per hectare in these districts comes as: N 16.21 kg, P 3.56 kg and K 2.12 kg.

In five other districts of Doab, viz., Aligarh, Etah, Mainpuri, Etawah and Allahabad the farmers consumed the nutrients of fertilizer between the range of 15 and 20 kg. per hectare. In other districts too, namely, Budaun, Gonda, Sultanpur, Pratapgarh and Azamgarh the levels of consumption were in accordance with the above districts of Doab i.e., between the range of 15 and 20 kg per hectare. The districts of Mathura, Agra, Kanpur and Fatehpur of Doab, Dehra Dun of Sub-Montane tract, Shahjahanpur, Kheri, Sitapur and Bahraich, Ballia and Ghazipur belong to the range of consumption between 10 and 15 kg per hectare. In them the nutrientwise consumption levels are as: N 83.0 kg, P 3.20 kg and K 1.30 kg. The remaining six districts, viz., Naini Tal, Hardoi, Rae Bareli, Mirzapur and all the districts of Bundelkhand except Jalaun show a level of NPK consumption less than 10 kg per hectare. Therefore, the nutrientwise consumption levels are far below the standard being as: N 3.92 kg, P 0.92 kg and K 0.60 kg per hectare.

(e) <u>Fertilizer Use in Relation to Irrigation and of HYV Programme</u>

Further, it has been attempted to illustrate the extent of variation between the inputs like food crops area under irrigation and of fertilizer use, and of food crops area planted under high-yielding varieties versus fertilizers (NPK) use in each of the forty-eight districts of the State during 1970-71.

In order to establish the relationship between the food crops area under irrigation (percentages to the cropped area)[6] and fertilizer input per hectare, and for the relationship between food crops area planted under HYV of seeds (percentages to the cropped area and fertilizer input, the horizontal and vertical axises of Figs.49 and 50 may be compared respectively. While comparing these, there seems to be a positive relation between the irrigation and of fertilizer use, which are the key components in the adoption of HYV programme in the districts of Muzaffarnagar and Meerut, in them the area under irrigation is estimated between the range of 70 and 80 per cent and of fertilizer use between 35 and 40 kg per hectare. Besides these, some other districts namely, Farrukhabad, Faizabad, Rampur,

6. Data from Table XXIV of Chapter VIII.

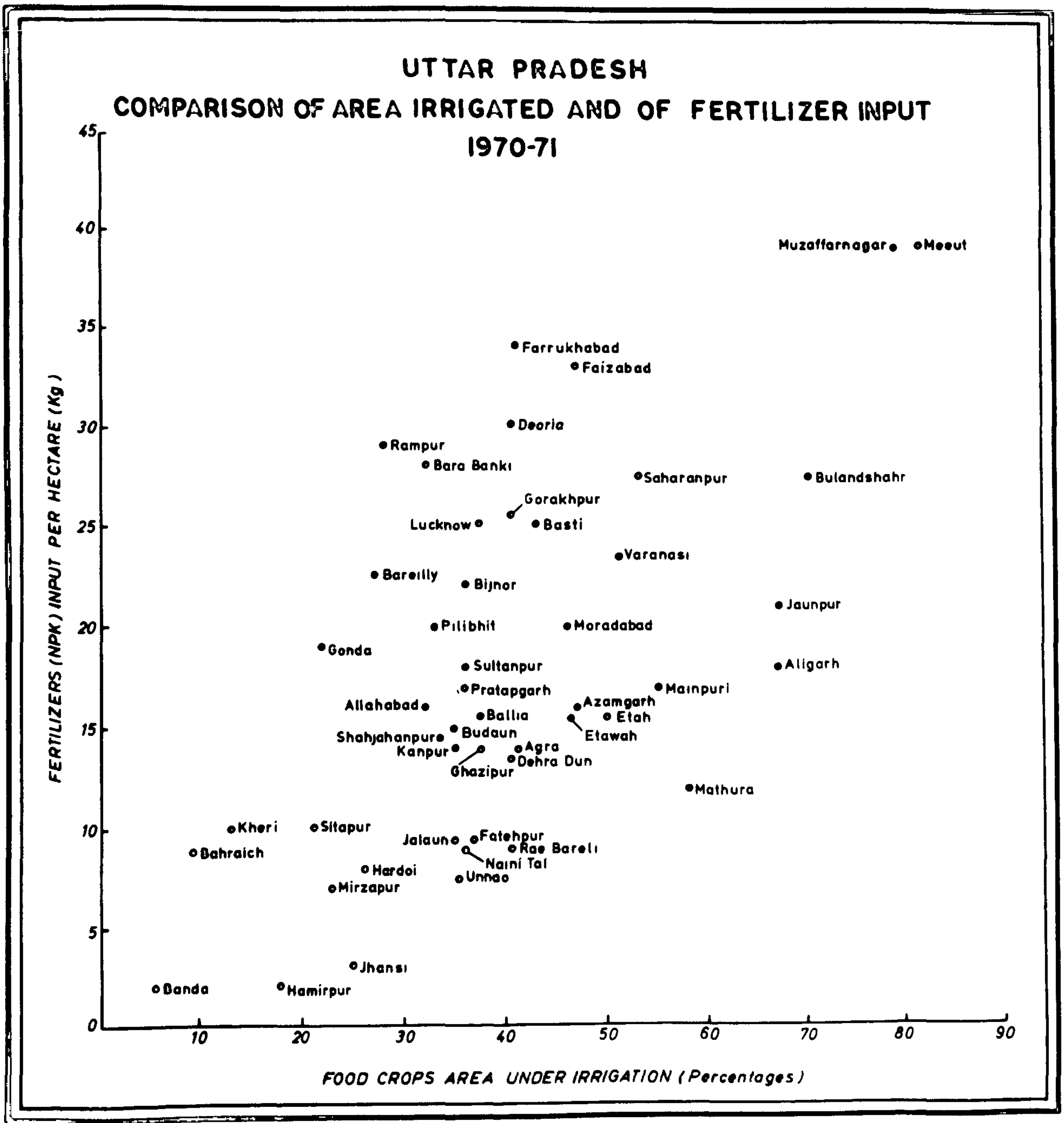
UTTAR PRADESH
COMPARISON OF AREA IRRIGATED AND OF FERTILIZER INPUT
1970-71
FERTILIZERS (NPK) INPUT PER HECTARE (Kg)
FOOD CROPS AREA UNDER IRRIGATION (Percentages)
0
5
10
15
20
25
30
35
40
45
10
20
30
40
50
60
70
80
90
Muzaffarnagar
Meeut
Farrukhabad
Faizabad
Deoria
Rampur
Bara Banki
Saharanpur
Bulandshahr
Gorakhpur
Lucknow
Basti
Varanasi
Bareilly
Bijnor
Jaunpur
Pilibhit
Moradabad
Gonda
Sultanpur
Aligarh
Pratapgarh
Mainpuri
Allahabad
Azamgarh
Ballia
Etah
Etawah
Shahjahanpur
Budaun
Kanpur
Agra
Dehra Dun
Ghazipur
Mathura
Kheri
Sitapur
Jalaun
Fatehpur
Rae Bareli
Bahraich
Naini Tal
Hardoi
Unnao
Mirzapur
Jhansi
Banda
Hamirpur

FIG. 49

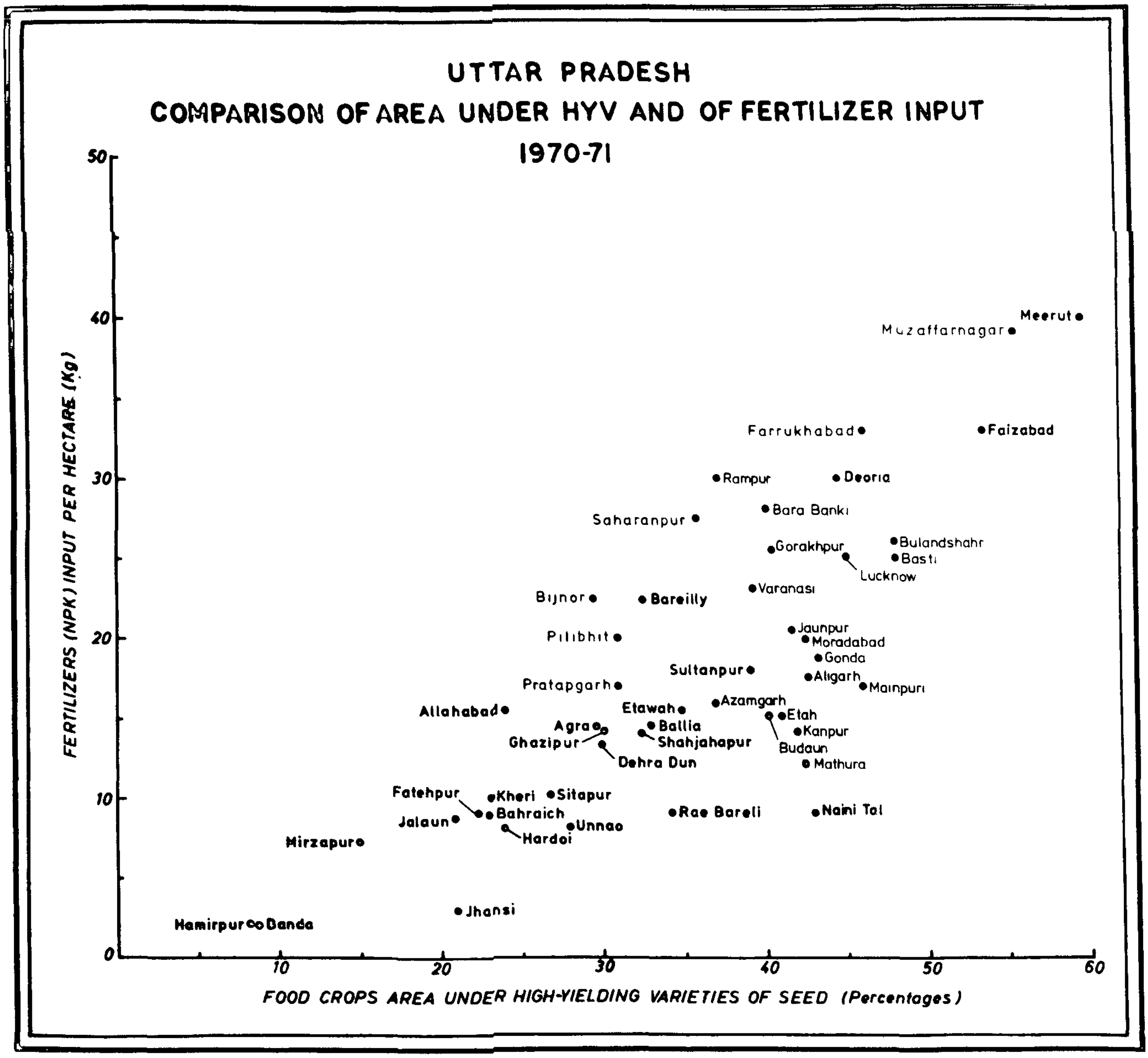
UTTAR PRADESH
COMPARISON OF AREA UNDER HYV AND OF FERTILIZER INPUT
1970-71
FERTILIZERS (NPK) INPUT PER HECTARE (Kg)
FOOD CROPS AREA UNDER HIGH-YIELDING VARIETIES OF SEED (Percentages)
0
10
20
30
40
50
60
Meerut
Muzaffarnagar
Farrukhabad
Faizabad
Rampur
Deoria
Bara Banki
Saharanpur
Gorakhpur
Bulandshahr
Basti
Lucknow
Varanasi
Bijnor
Bareilly
Jaunpur
Pilibhit
Moradabad
Gonda
Sultanpur
Aligarh
Pratapgarh
Mainpuri
Azamgarh
Allahabad
Etawah
Etah
Agra
Ballia
Kanpur
Ghazipur
Shahjahapur
Budaun
Dehra Dun
Mathura
Fatehpur
Kheri
Sitapur
Bahraich
Rae Bareli
Naini Tal
Jalaun
Unnao
Hardoi
Mirzapur
Jhansi
Hamirpur
Banda

FIG. 50

Saharanpur, Deoria, Bulandshahr and Bara Banki too have the positive relationship (Fig.49). Whereas the districts of Jhansi, Jalaun, Hamirpur and Banda of Bundelkhand tract, and of Mathura, Agra, Fatehpur, Unnao, Rae Bareli, Sitapur, Hardoi, Kheri and Bahraich have the low relation. The other remaining districts lie in between these two extremes.

While comparing the relation between area under HYV (percentages) and of fertilizer input per hectare (Fig.50), there are substantial indications to recognise most the districts which fall at the same position as were indicated in the case of irrigated area versus fertilizer consumption.

C. FARM IMPLEMENT AND MACHINERY IN USE

It has been proved beyond doubt that when used judiceously form implement and machinery can play a very important role in increasing agricultural production. The operations in agriculture depend upon various resources available with the farmer of which power and equipment are of considerable importance and deserve due consideration. It has been estimated that the animal energy costs Rs.1.00 per horsepower hour and mechanical Re.0.40 per horsepower hour. By using tractor power we can reduce the operation cost over 50 per cent and speed up the work five times.[7] In agricultural production process, a number of operations from preparation of seed bed to the final processing of products to be included and a number of mechanical operations are required to be utilized at all stages to achieve the higher efficiency. Thus, in order to make the agriculture productive and profitable, efficient and time saving devices like tools, implements and machinery should be brought in use to minimise the production cost as well as time required per agricultural operation. Table XXXV shows the number of form implements and machinery brought in use in State agriculture since 1961.

TABLE XXXV

Farm implement and machinery brought in use in U.P.- A trend of progress

Census Year	1961		1966		1972	
Agricultural implement/machinery	Numbers		Numbers		Numbers	
	Total	Per 1000 ha.	Total	Per 1000 ha.	Total	Per 1000 ha.
Iron Plough	4,96,911	22.50	9,28,507	43.43	16,81,408	76.29
Tractor	7,139	0.32	10,139	0.47	43,762	1.98
Seed drill	N.C.	-	7,581	0.35	2,07,498	9.41
Plant protection equipment	N.C.	-	6,698	0.31	96,165	4.36
Pumping set for irrigation	11,377	0.53	38,343	1.79	3,11,887	14.14
Thresher	N.C.	-	14,036	0.65	77,949	3.53

N.C. = Data not collected.
Source: State Agricultural Census Office, Lucknow.

7. Vangari, S.S., "Engineering and Power Energy Aspects in Relation to Cropping Patterns in Maharashtra", Proceedings of the Symposium on Cropping Patterns in India, (I.C.A.R., New Delhi, 1971), p.549.

Figures produced in the table exhibit also a trend of progress in respect to their total distribution in numbers and distribution per 1000 hectares in the State in relation to the cropped land as well as during the last three census years. We can observe a substential signs of transformation of traditional agricultural systems into mechanical ones. Both the quantum and intensity of improved iron ploughs doubled in relation to cropped land since 1961 to 1966 and subsequently between the period 1966 and 1972. The usage of tractors also shows an encouraging trend, specially between the period 1966 and 1972 in which number of tractors (including crawler tractor, power tiller and four wheel tractor) in use recorded as 10,139 during 1966 and 43,762 during 1972. An increase in the use of seed drills and plant protection equipment can also be noticed between these two successive years. A change in the number of pumping sets for irrigation may be visualised by accounting less than one set in 1961, which increased upto 2 and 14.14 per 1000 hectares of irrigated land during 1966 and 1972 respectively. The progress in threshers use on the farms accounted about 14,000 in 1966 and 78,000 in 1972. Their intensity of use in relation to cropped land stands as less than 1 thresher in 1966 and about 3.5 per 1000 hectares subsequently in 1972.

(a) Levels of Mechanization

Agricultural implements and machinery in use enumerated during the last livestock Census Year 1972 in each district of the State are listed in Appendix XVII and Table XXXVI is based on values of each item computed in relation to cropped land (1970-71) i.e., numbers of machinery in use on per 1000 hectares. It is evident from the table that the use of farm machinery is not uniform and there are substantial variations in the levels of farm mechanization in different parts of the State.

(i) Improved Iron Ploughs

The improved iron ploughs figures show that the highest intensity of these is found in the districts of Etawah, Pilibhit, Farrukhabad, Saharanpur, Naini Tal, Kanpur, Kheri, Azamgarh and Hardoi in them the figures ranges in between 123 (Hardoi) and 217 ploughs (Etawah) on per 1000 hectares. And the area brought per plough ranges between 4.6 and 8 hectares in the above mentioned districts. Besides these, the second range between 90 and 120 ploughs per 1000 hectares is found in eight districts, and where the relation of land and plough exist as area between 8 and 10 hectares per plough (Table XXXVI). In the remaining

TABLE XXXVI

Districtwise distribution of agricultural machinery in U.P. - 1970-71

(Nos. per 1000 hectares)

Name of district	Iron plough	Tractor	Pumping set for irrigation	Thresher
1	2	3	4	5
Dehra Dun	60.48	2.29	168.60	0.98
Saharanpur	166.98	4.56	25.81	6.42
Muzaffarnagar	106.43	18.57	38.95	10.19
Meerut	60.18	7.15	20.73	12.32
Bulandshahr	13.01	2.76	19.14	9.98
Aligarh	16.88	1.38	9.93	3.96
Mathura	12.02	3.71	14.92	2.28
Agra	41.66	2.48	24.10	3.33
Mainpuri	114.20	2.44	21.47	4.93
Etah	73.54	1.59	11.74	2.51
Bareilly	119.82	1.36	11.21	1.57
Bijnor	119.38	2.59	21.02	4.71
Budaun	112.34	0.65	8.50	2.79
Moradabad	24.87	1.80	19.95	4.96
Shahjahanpur	123.34	1.38	22.44	2.95
Pilibhit	176.17	2.96	17.21	5.37
Rampur	64.49	5.00	17.19	3.01
Farrukhabad	170.84	1.34	19.66	5.05
Etawah	220.03	0.71	14.53	3.64
Kanpur	144.14	0.76	15.73	2.60
Fatehpur	92.13	0.18	11.46	2.95
Allahabad	48.29	0.56	8.66	0.55
Jhansi	0.86	0.91	3.61	0.42
Jalaun	9.39	3.09	2.02	0.44
Hamirpur	8.82	0.67	4.09	0.30
Banda	46.28	0.12	2.74	0.00

(contd....)

TABLE XXXVI (Contd....)

1	2	3	4	5
Varanasi	98.03	1.04	12.18	2.33
Mirzapur	51.21	0.96	6.29	0.77
Jaunpur	46.33	0.58	17.23	2.35
Ghazipur	36.31	1.16	16.48	2.97
Ballia	23.95	0.55	8.75	2.88
Gorakhpur	93.46	1.26	15.47	5.49
Deoria	60.40	1.49	14.20	8.06
Basti	65.73	0.72	11.92	4.20
Azamgarh	136.71	0.47	14.30	2.89
Naini Tal	157.84	2.13	14.57	3.56
Lucknow	79.84	0.63	11.52	0.22
Unnao	82.13	0.59	11.09	1.40
Rae Bareli	48.04	0.21	10.84	1.04
Sitapur	83.09	0.60	14.34	3.26
Hardoi	125.85	0.67	9.33	1.97
Kheri	133.62	2.25	12.86	2.17
Faizabad	83.28	0.88	17.62	2.89
Gonda	48.37	0.98	9.38	3.24
Bahraich	85.73	0.43	5.93	1.31
Sultanpur	16.05	0.15	5.93	0.49
Pratapgarh	10.21	0.45	10.81	0.12
Bara Banki	28.82	0.97	9.49	6.42
Uttar Pradesh	76.29	1.98	14.14	3.53

districts it can be observed, that as the range of number of ploughs is decreases in certain district/districts the relation between land and ploughs increases.

(ii) <u>Tractors</u>

The distribution and intensity of tractors use can be judged from Fig.51 which is based on the figures produced in Appendix XVII for each district of the State. With reference to average area of cropped land (1970-71) and number of tractors in use (1972) it is quite possible to recognize six different demarcated regions of:
(i) cropped land less than 400 hectares per tractor;
(ii) between 400 and 800 hectares; (iii) between 800 and 1,200 hectares; (iv) between 1,200 and 1,600 hectares; (v) between 1,600 and 2,000 hectares, and (vi) over 2,000 hectares. Shaded areas correspond roughly to the cropped land. It is apparent from the figures that the areas with a high tractor density are in the upper and middle Ganga-Yamuna Doab where the farmers are intended to use intensive farming methods. Here in these districts the distribution of tractors in use ranges between about 2 and 7 tractors per 1000 hectares in Agra and Meerut respectively and the value for Muzaffarnagar district is about 18 tractors per 1000 hectares. In other districts where the intensity of tractor use is of high order are: four districts of

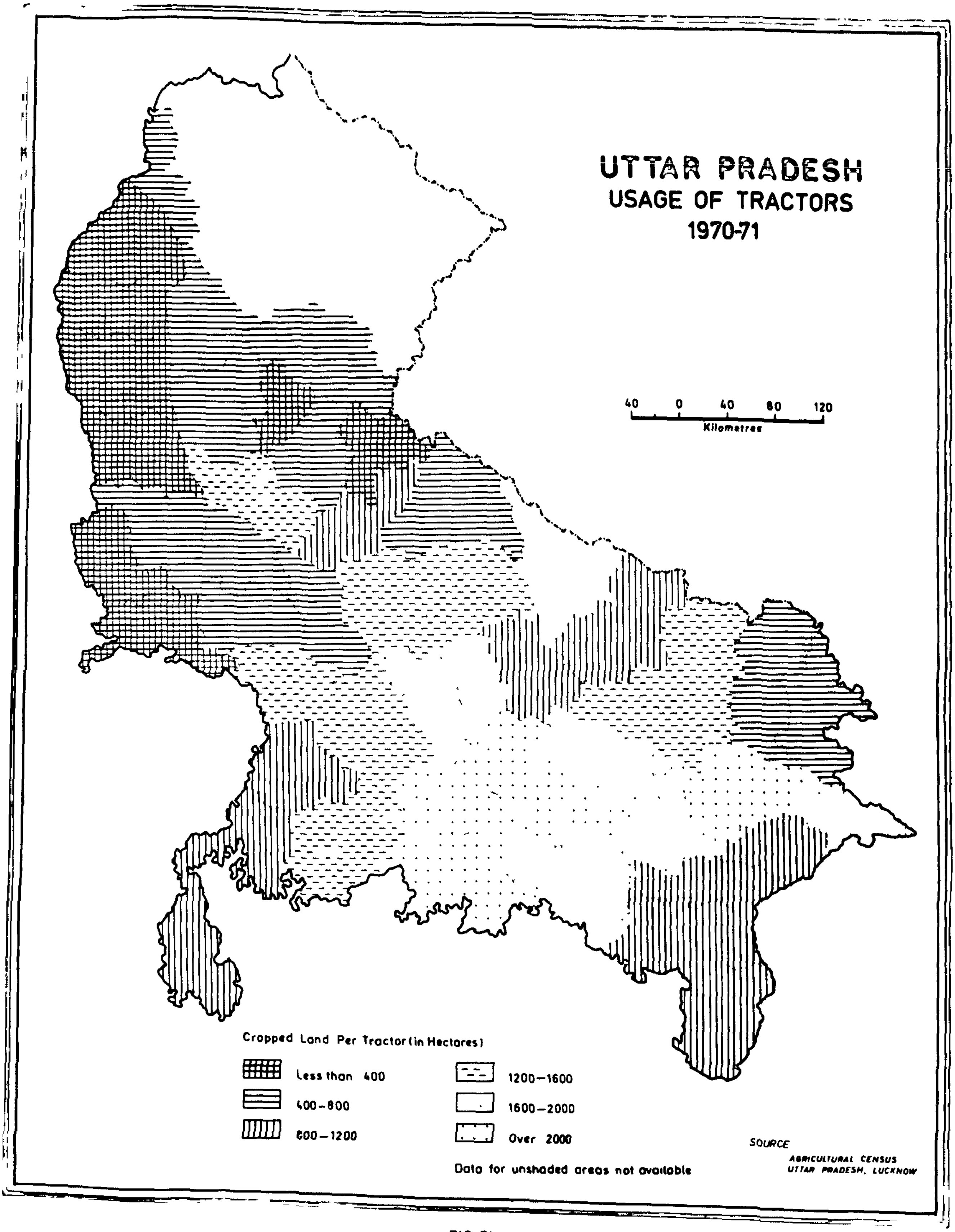
UTTAR PRADESH
USAGE OF TRACTORS
1970-71
40 0 40 80 120
Kilometres
Cropped Land Per Tractor (in Hectares)
Less than 400
400-800
800-1200
1200-1600
1600-2000
Over 2000
Data for unshaded areas not available
SOURCE
AGRICULTURAL CENSUS
UTTAR PRADESH, LUCKNOW

FIG. 51

middle Doab namely, Aligarh, Mainpuri, Etah and Farrukhabad, three districts of Rohilkhand region namely Bareilly and Bijnor, two districts of Trans-Ghaghara tract, viz., Gorakhpur and Deoria, and Dehra Dun and Naini Tal of sub-Montane tract where the land per tractor comes between the range of 400 and 800 hectares and the distribution of tractor ranges between about 1 and 2 per 1000 hectares. In other districts the value of distribution is less than 1 tractor per 1000 hectares and the figures of cropped land per tractor exceeds more than 1000 hectares.

(iii) <u>Use of Animal and Tractor Power</u>

Power use and its availability is considered to be an indispensable tool for exhancing the agricultural productivity per hectare and per man-hour of work.[8] Its extent of application therefore, has been regarded a component of agricultural development. Randhawa, has stressed its importance in these words:[9]

> "The state of progress of industry or agriculture is fairly and accurately represented by the power use index".

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8. F.A.O., <u>Essential Considerations in Mechanization of Farming</u> (Washington, 1950), p.1.
9. Randhawa, M.S., <u>Green Revolution</u> (New Delhi, 1974), p.141.

The term 'power use in agriculture' refers generally to the power contributed by man, animal and machinery engaged in agriculture. The index of energy used in agriculture can either be obtained by dividing the number of energy sources by the total cropped area to get the value per hectare or converting them to a certain uniform scale e.g., horsepower equivalent[10] in relation to cropped land/agricultural population in a study area.

Taking into consideration the figures of animal (bullocks over three years of age) and tractor an attempt has been made to analyse the availability of power indices (horsepower units) per 1000 hectares of cropped land as well as per 1000 agricultural workers to per form the work in each of the forty-eight districts considering the statistics of agricultural census year 1972 and of agricultural population for the census year 1971. The cropped area relates to 1970-71 figures. It has been assumed that an animal (bullock) be expressed as equivalent to 0.25 horsepower, and a tractor as equivalent to 30 horsepower.[11] The magnitude of power input (animal and

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10. F.A.O., Smaller Farmlands Can Yield More, Rome, 1969, pp.35-6.
11. Maharashtra Economic Development Council, Agro-Industries in Maharashtra- Problems and Prospects, Bombay, 1970, Qouted by Shinde, S.D., and Jadhav, M.G., "Use of Energy in Agriculture in Sangli District: A Geographical Analysis", G.R.I., Vol.40, No.2, 1978, p.101.

tractor power) in each district may be visualised from Table XXXVII which show the total animal and tractor power and also the percentage share of tractor power used. And Fig.52 measures the availability and extent of animal and tractor power used in relation to cropped land and of agricultural work force in agriculture. The extent of animal and tractor power has been measured on the horizontal axis and the vertical axis measures the animal and tractor power available for performing work per 1000 agricultural workers during the year 1970-71. A direct relationship between power input per 1000 hectares and per 1000 agricultural workers is clearly visible at a fair number of districts, specially for the districts of Muzaffarnagar and Naini Tal, in them the power values are 648.61 and 1,146.82 units per 1000 hectares, and 817.41 and 1,842.12 units per 1000 workers respectively (Table XXXVII). In other districts, the more marked associations of animal and tractor power per 1000 hectares and 1000 workers are in between the range of 250 and 350 horsepower units (Fig.52). Here the farmers are intended to use greater power. And a reverse relation also exist at a good number of districts namely the districts of Etawah, Kanpur, Fatehpur, Banda, Rae Bareli, Sitapur, Ballia etc. where power availability per 1000 workers ranges between 75.42 (Etawah) and 193.38 (Sitapur) horsepower units for performing work.

TABLE XXXVII

Districtwise animal and tractor power used in agriculture in U.P. - 1970-71

(in terms of horsepower units)

Name of district	Power per 1000 hectares	Power per 1000 agricultural workers	Tractor power as percentage of total non-human power
1	2	3	4
Dehra Dun	235.82	259.60	28.24
Saharanpur	241.70	344.76	56.42
Muzaffarnagar	648.61	817.41	86.13
Meerut	289.99	411.70	68.55
Bulandshahr	189.51	274.06	44.52
Aligarh	129.73	193.74	33.22
Mathura	187.19	303.90	59.91
Agra	149.52	200.97	51.18
Mainpuri	154.00	182.93	47.99
Etah	155.55	187.27	30.94
Bareilly	156.36	169.41	25.85
Bijnor	213.30	307.52	34.69
Budaun	146.04	163.63	13.30
Moradabad	191.31	231.47	28.17
Shahjahanpur	142.57	168.01	26.03
Pilibhit	197.70	279.61	45.28
Rampur	253.39	323.64	58.29
Farrukhabad	151.89	168.18	26.28
Etawah	75.42	92.21	28.20
Kanpur	92.48	107.41	2.46
Fatehpur	145.07	139.57	3.73
Allahabad	216.98	192.55	7.60
Jhansi	231.20	435.80	11.81
Jalaun	166.33	336.01	57.19
Hamirpur	124.40	236.08	16.44

(contd.....)

TABLE XXXVII (contd....)

1	2	3	4
Banda	107.30	174.16	3.57
Varanasi	205.34	191.81	14.84
Mirzapur	196.30	212.93	14.16
Jaunpur	243.16	207.06	7.26
Ghazipur	206.60	190.64	15.36
Ballia	167.01	137.04	9.88
Gorakhpur	229.89	178.33	16.38
Deoria	193.61	153.74	22.75
Basti	237.59	193.11	9.61
Azamgarh	227.17	187.51	6.05
Naini Tal	1,146.38	1,842.12	5.86
Lucknow	218.68	191.94	8.49
Unnao	197.07	201.04	8.72
Rae Bareli	217.24	195.93	2.93
Sitapur	193.38	189.28	9.16
Hardoi	187.02	192.97	10.68
Kheri	188.76	244.64	34.79
Faizabad	446.86	367.12	5.18
Gonda	224.03	221.47	13.04
Bahraich	146.96	157.53	8.17
Sultanpur	240.53	211.98	1.90
Pratapgarh	282.24	230.61	4.70
Bara Banki	220.00	191.97	12.98
Uttar Pradesh	197.23	224.05	28.68

UTTAR PRADESH

ANIMAL AND TRACTOR POWER USED IN AGRICULTURE

(Horsepower Units)

1970-71

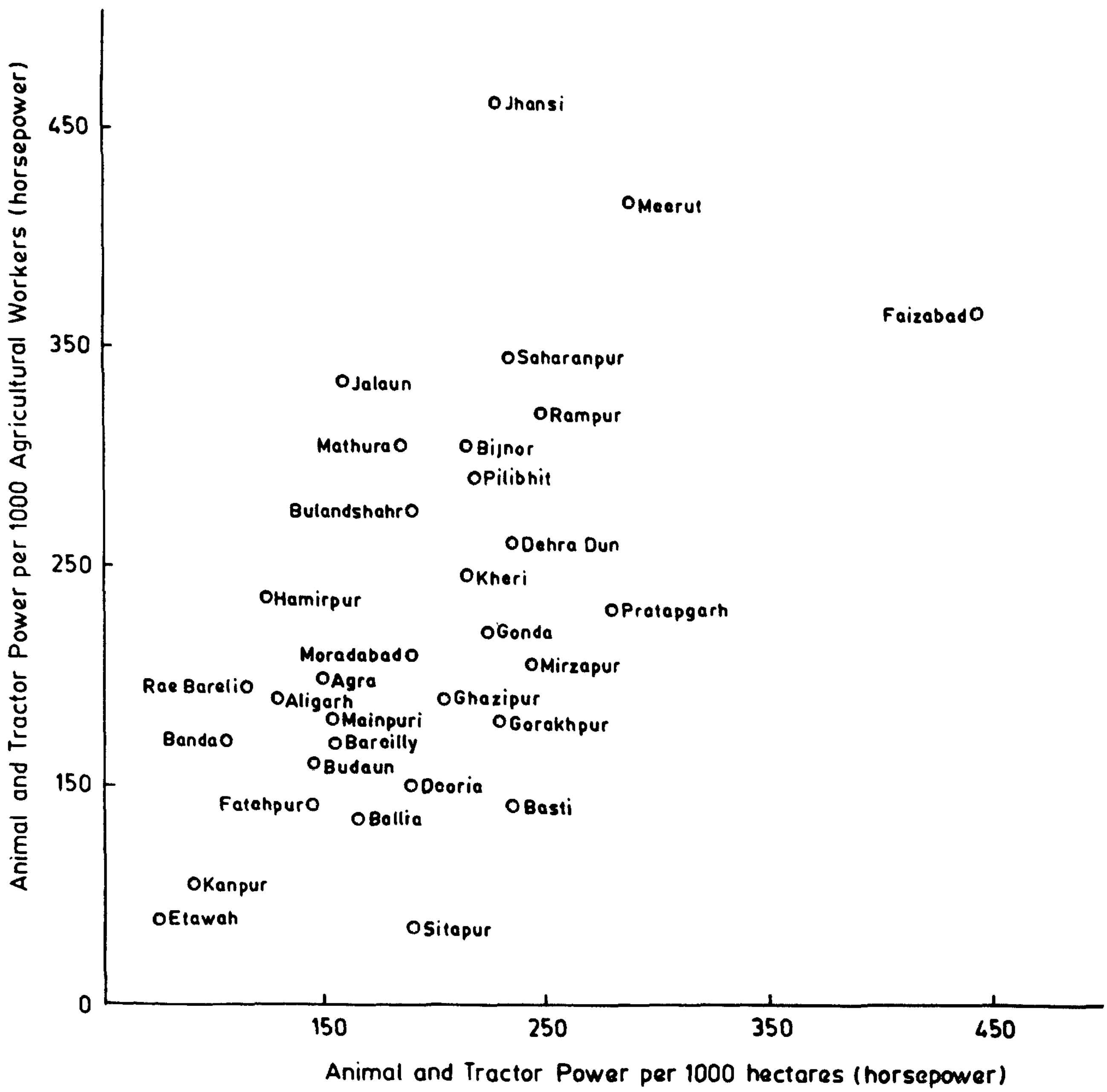

FIG. 52

(iv) Pumping Sets for Irrigation

Total number of pumping sets (diesel and electrical) for irrigation purposes have been produced in Appendix XVII and Fig.53 based on the value of pumping sets computed in relation to area irrigated in each district during 1970-71. It is clear from the map, that the intensity of pumping sets used for irrigation purposes is low in the areas where canals and tube-wells constitutes the major source of irrigation especially the whole of the Ganga-Yamuna Doab (with few exceptions). On the other hand in the districts in which other sources of irrigation contribute the share the density of pumping set is high for instance in the districts of Kheri, Sitapur and Bahraich in them the irrigated area per pumping set stands less than 16 hectares. Most of the districts of the State posses area irrigated per pumping set between the range of 26 and 31 hectares, 31 and 36 hectares and more than 36 hectares (Fig.53). Among them are Meerut and Bulandshahr districts of upper Doab, Aligarh, Mathura and Etah of middle Doab, an extensive parts of eastern region, and the whole of the Bundelkhand region.

(v) Threshers[12]

Greater use of threshers too is oriented to some agriculturally advanced regions of the State and where

12. For rice, wheat and other crops included.

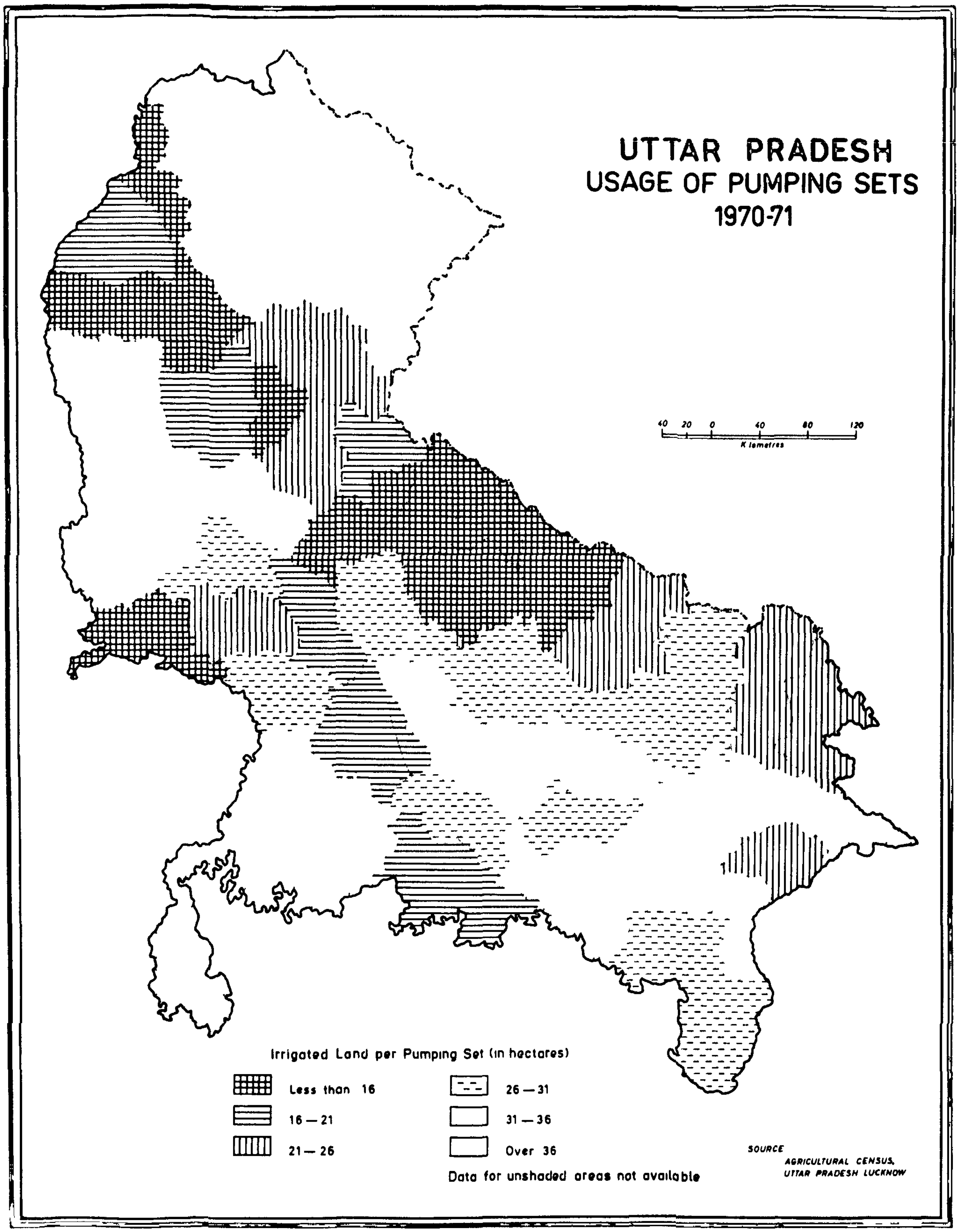
UTTAR PRADESH
USAGE OF PUMPING SETS
1970-71
40 20 0 40 80 120
Kilometres
Irrigated Land per Pumping Set (in hectares)
Less than 16
16 — 21
21 — 26
26 — 31
31 — 36
Over 36
Data for unshaded areas not available
SOURCE
AGRICULTURAL CENSUS,
UTTAR PRADESH LUCKNOW

FIG. 53

farmers are engaged to involve recent know how in the agricultural production process to minimise the lossess and to maximise the returns. Mechanical threshing is frequently done in all the districts of upper Doab namely, Saharanpur, Muzaffarnagar, Meerut, and Bulandshahr, and some other districts of Gorakhpur, Deoria, Bara Banki and Pilibhit where more than 5 threshers constituted the share for threshing per 1000 hectares. In other districts the use of threshers per 1000 hectares is computed in between 3 and 5 threshers, and they are Farrukhabad, Moradabad, Mainpuri, Bijnor, Aligarh, Basti, Etawah, Agra, Rampur, Naini Tal, Gonda and Sitapur, (Table XXXVI). Besides these in thirteen districts the density of threshers for work is in between 2 and 3 threshers per 1000 hectares. In the remaining fifteen districts the use of threshers ranges between 1 and 2 threshers in five districts of Hardoi, Bareilly, Unnao, Bahraich, and Rae Bareli, and in the last ten district threshing with the help of threshers is being done less than the figure of 1 thresher per 1000 hectares. Thus, it is clear from the foregoing discussion, that there are sufficient variations in the use of mechanical devices in different parts of the State.

D. AGRICULTURAL CREDIT

The farm potentiality and new scientific knowledge are of no value in pushing up agricultural productions if the farmers do not have the necessary investments required for adopting the recommended patterns and practices on their holdings. As mentioned earlier, that in Uttar Pradesh there is a preponderance of small holdings as of about 80 per cent are below 3.5 hectares. Evidently, there is a sizeable segment of sub-marginal, marginal and small farmers who have the land resources but are handicapped to venture for its maximum exploitation due to the limitation of poor capital availability. Therefore, the State Co-operative Banks and the State Agriculture Department have taken responsibility to finance the farmers at various levels to meet the expanses on agriculture.

(a) Co-operative Movement in the State

With the advent of green revolution the agriculture started getting modernised, and more and commercialised in the State, thereby, resulting in an enormous increase in the demand of credit. In Uttar Pradesh, the Co-operative Movement has shown a multichannel improvements. The credit giving institutions not only provide their possible assistance the agricultural purposes, but also help the farmers to market their produces for maximising the returns. The assistance provided to the farmers in the credit structure consists of the advances into two forms as: kind and cash. In the kind form, a farmer is assisted by providing seeds of high-yielding varieties, fertilizers, pesticides and modern agricultural implements. In both the forms (kind and cash) the maximum credit limit to the farmers has been fixed as follows:

Name of crop	Maximum credit limit per hectare		
	Kind form (in Rs.)	Cash form (in Rs.)	Total
Sugarcane	250	250	500
Other crops	125	125	250

In the adoption of HYV programme, the co-operative institutions play a very important role. They arrange to purchase the seeds of new Mexican wheat varieties and hybrid varieties for other crops to distribute among the farmers. The farmers of the State also get chemical fertilizers insecticides and credit (kind and cash) through these institution's to promote the present agricultural conditions and the living standard of the agricultural population. In order to provide a quick and regular arrangement in credit system, the District Co-operative Banks have been directed to open their new branch offices at tehsil and block level in the district. It is expected, that in the near future every development block would be benifitted with the opening of a branch office of these banks to advance credit for promoting the means of irrigation in substantial forms. These banks also pay special attention towards the construction and establishment of warehouses for stocking fertilizers and their proper distribution in time, during the crop season.

It is intended, that the potato growers will also be benifitted by extending cold storage capacity and by the construction of new ones. This is one of the central themes of co-operative planning.

In order to bring stability in the advancement of credit system the Co-operative Banks have adopted Reserve Bank's 'Master Plan' scheme by which small and medium class farmers are categorised to receive the maximum benifits. The purpose of the scheme is that, all the households of agricultural class have right to be the member and to borrow the medium term credit. Provisionally, a farmer is entitled to receive an advance within the range of Rs.20-100 per hectare.

In rural areas, there is a continuous awareness for the adoption of new techniques of modern agriculture.

Therefore, it is necessary that the owners of tractor, power tiller and other agricultural implements should have the facilities for servincing them within the village itself at a proper and reasonable rates. So to say, in the rural areas centres are being opend for the repair and servicing the machines. The primary objective of these centres is to provide agricultural machinery on hired basis and also to take care of for cleaning, repairing and assembling parts in their workshops. Besides this, they also arrange to provide spare parts, petrol and diesel oil to the farmers.

Obviously, it is clear that State co-operatives have made a good headway. A three-tier co-operative credit structure has been evolved in the State in view of the credit requirements of the farmers. At the village level, there are Primary Agricultural Credit Societies and at the district level 56 District Central Co-operative Banks in each of the 54 districts (2 each in Saharanpur and Agra). There were 526 branch offices of these banks in different areas of the State. And at the State level the Uttar Pradesh Co-operative Bank is functioning.

(b) Role of Primary Agricultural Societies

A primary agricultural credit society means a co-operative society. The primary object or principal business of which is to provide financial assistance to its members for agricultural purposes and purposes connected with other agricultural activities (including marketing of crops). Table XXXVIII shows a trend of progress of these societies and their assets during the three decennial years.

These societies distributed loans basically for the purchase of inputs for the production of foodgrains and other agricultural products. The advancement of loans is on the basis of <u>kind</u> and <u>cash</u> schedules. In view of the growing demand, the credit schedules have been fixed as: A member can borrow the short term credit upto Rs.5,000 for the purchase of inputs of which Rs.1,500 will be given in <u>cash</u> and the remaining will be in the <u>kind</u> form. The short term credits are given conditionally. Therefore, they are advanced only for the crop season and the farmers are bound to return after the crop harvest.

The Reserve Bank of India emphasized while assessing the farmer's credit needs, that the success of green revolution should not be restricted upto some large and well-off farmers but the medium and small class farmers must also be benifitted upto the mark, from it. Consequently, the government of Uttar Pradesh has adopted

TABLE XXXVIII

Purposewise credit advanced by Primary Agricultural Credit Societies in U.P. - A trend of progress

Itemwise details	1950-51	1960-61	1970-71
Number of societies	26,390	55,131	25,922
Villages under societies (in %)	39	100	100
Number of memberships (in thousand)	850	3,340	5,527
Average membership per society	32	61	213
Credit advanced(in thousand Rs.)	22,825	3,09,779	5,13,421
Short term credit advanced (in thousand Rs.)	N.A.	3,09,128	4,83,603
	Per cent to the total advancement		
Seasonal agricultural operations	-	78.10	90.60
Purchase of agricultural implements	-	7.40	5.50
Other purposes	-	9.80	1.70
Medium term credit advanced (in thousand Rs.)			
	Per cent to the total advancement		
Sinking of or repair to wells	-	-	6.20
Purchase of machinery	-	1.50	8.3
Minor improvements in land	-	24.00	7.10
Purchase of cattle	-	45.00	63.30
Other purposes	-	29.50	5.10

N.A. = Data not available

Source: Office records Registrar Co-operative Banks, Uttar Pradesh, Lucknow.

the Master Plan scheme initiated by the Reserve Bank of India with a view that the quantity of the credit advanced by the co-operative institutions be enhanced upto a satisfactory level.

Table XXXVIII shows a trend of progress and details of purposewise credit advanced to the farmers in Uttar Pradesh during two successive decennial years i.e., 1960-61 and 1970-71. As the details of purposewise loans for the year 1950-51 are not available, therefore, figures pertaining to the above two periods have been produced. Regarding the number of societies the year 1960-61 shows more or less double figure in comparison to its preceeding and succeding decennial years. During 1950-51 these societies covered only 39 per cent of the villages to finance the farmers of the State. Later on in 1960-61 and 1970-71 their activities extended to cover all the remaining villages. The societies are actively engaged to offer the memberships to the peasant class. During 1950-51 there were about 0.85 million memberships with them and this figure rose upto 3.34 million and 5.53 million subsequently in between 1960-61 and 1970-71. With the increase of memberships the average figure of membership with each society is on the increase. There were only 32 members as an average per society during 1950-51, but in the next two decennial years of 1960-61 and 1970-71 each society financed 61 and 213 members respectively. And the total advances by them ranged about Rs.22.82 million during 1950-51, about Rs.31.00 million in 1960-61 and during 1970-71 the amount rose upto Rs.51.34 million.

The distribution of short and medium term loans are being recorded purposewise under different categories, and these short and medium term loans have been defined as:

> "Short-term outstandings are those which relate to loans and advances repayable within a period not exceeding 15 months...",[13] and the "....medium-term loans are those which are repayable over a period not less than 15 months and generally within 5 years from the date of advance....".[14]

In short term credit structure, there are three important purposewise categories in which a farmer can borrows the credit:

(i) Seasonal Agricultural Operations

This head refers to loans distributed to the farmers to meet the expanses during seasonal agricultural

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13. The Reserve Bank of India, Hand Book of Concepts and Definitions of Terms Used in the Compilation of Statistical Statements Relating to the Co-operative Movement in India (Bombay), 1973, p.7.
14. ibid., p.14.

operations. These loans usually given either in kind or cash form e.g., in the form of fertilizers, improved seeds, pesticides etc. The cash credits are given for the purchase of seed, manure and fertilizer, payment of wages, operations like digging, sowing, transplanting, weeding, harrowing, harvesting, threshing, effective minor repairs to bunds etc., and also for meeting some maintenance expenditure of the cultivators during the pre-harvesting season. The Primary Agricultural Societies alloted the highest percentage of advances to this category of short term credit period during both the decennial years i.e., 1960-61 and 1970-71 as about 78.10 and 90.60 per cent respectively.

(ii) Purchase of Agricultural Implements

This head refers to loans given in cash forms for the purchase of implements like ploughs, shovels and pick-axis etc. Therefore, under this category the societies allotted about 7.40 per cent of the total advances in 1960-61 and in the subsequent decennial year 1970-71, this allotment reduced to a share of about 5.50 per cent. This reduction of amount under this category lead to enhancement of amount to the category of seasonal agricultural operations in which it shows an increase of 12.50 per cent while comparing it to the previous year i.e., between 1960-61 and 1970-71.

(iii) Other Agricultural Purposes

This column relates to advancement of loans by Primary Agricultural Societies and Marketing Societies for such purposes, as of stocking and distribution of agricultural requisitos like fertilizers, seeds, insecticides and small agricultural implements. During 1960-61 these societies advanced about 9.80 per cent of total advanced but this percentage reduced in 1970-71 and its share remained only 1.7 per cent under this head.

There are five major heads of medium term credit structure in which a farmer borrows the credit:

(i) Sinking of or Repair to Wells

This head includes the advancement of loans for sinking of new wells, construction of tanks, deepening and repairs to old wells and tanks etc. During 1970-71 these societies spend about 6.2 per cent of the medium term credit and preceeding to this year no emphasis was given to this head.

(ii) Purchase of Machinery

This category includes the advancements of loan for the purposes like the purchase and installation of persian wheels, diesel and electric pump-sets, purchase of machinery and implements like tractors, power tillers etc., and transport equipments. Evidently, the process of mechanical cultivation was switched on in the State with the introduction of HYV programme, therefore, during 1960-61 the amount given under this head accounted only 1.5 per cent but in 1970-71 this share raised upto 8.3 per cent of the total medium credit by these societies.

(iii) Minor Improvements in Land

This category of loans advancement includes the purposes like levelling, bunding, fencing, preparation of land for orchards and plantation etc. During 1960-61 the farmers of the State received about 24 per cent of the total medium term loan under this category, but during 1970-71 it reduced to 7.1 per cent. It seems that the amount transfered to some other categories.

(iv) Purchase of Cattle

Under this head the farmers are given loans for the purchase of bullocks and milch-cattle. The largest amount of advances are given in this category as about 45 per cent of medium term credits were given to the farmers and this share subsequently raised to 63.3 per cent during 1970-71.

(v) Other Agricultural Purposes

This head covers the requirements of the farmers as construction of godowns, farm houses, cattle-sheds etc. etc. For these purposes about 29.5 per cent out of the total medium term credit was allotted in 1960-61 and during 1970-71 this share reduced to 15.1 per cent due to transfers of money to some other categories.

(c) Districtwise Agricultural Credit Levels

In Uttar Pradesh, the purposewise loans distributed to the farmers in each of the fortyeight districts and their details (short and medium term) are produced in the Appendix XVIII. Table shows distribution of (purposewise) short and medium term loans (in aggregate) and their distribution on 1000 hectares of cropped land in each district during 1970-71. Fig.54 shows the distribution of short and medium term credit(in aggregate) on per 1000 hectares by the Primary Agricultural Credit Societies in the districts of Uttar Pradesh. It is evident from the table that the total distribution of loans under short and medium categories varies to a greater extent in the State. A large number of farmers belonging to the districts of Doab usually received the the highest amount of agricultural credit, such as in Meerut Rs.38.70, Saharanpur Rs.30.19, Bulandshahr Rs.30.05,

TABLE XXXIX

Districtwise credit advanced by Primary Agricultural Credit Societies in U.P. -1970-71

Name of district	Distribution (in '000 Rs.)			Distribution (Rs. per 1000 hectares)		
	Short term	Medium term	Total	Short term	Medium term	Total
1	2	3	4	5	6	7
Dehra Dun	6,054	1,956	8,010	73,848.18	23,969.55	97,707.84
Saharanpur	29,932	259	30,191	54,101.24	468.13	54,569.37
Muzaffarnagar	17,959	209	18,168	37,572.70	468.93	38,009.95
Meerut	38,034	668	38,702	54,097.64	950.12	55,047.76
Bulandshahr	29,943	115	30,058	51,982.93	199.64	52,182.57
Aligarh	10,239	31	10,270	17,246.54	52.21	17,298.75
Mathura	20,997	2,130	23,127	51,572.95	5,231.71	56,804.66
Agra	8,017	330	8,347	18,113.13	745.58	18,858.71
Mainpuri	7,797	6	7,803	19,906.65	15.31	19,921.96
Etah	5,838	476	6,314	13,047.41	1,063.81	14,111.22
Bareilly	8,756	516	9,272	20,375.67	1,200.75	21,576.42
Bijnor	18,489	656	19,145	44,021.84	1,561.91	45,583.75
Budaun	8,689	370	9,059	16,860.25	717.95	17,578.20
Moradabad	20,359	118	20,477	32,169.47	186.45	32,355.92
Shahjahanpur	4,286	141	4,427	10,276.67	358.08	10,614.75
Pilibhit	4,908	9	4,917	17,463.20	32.02	17,495.22
Rampur	4,819	140	4,959	22,191.62	644.70	22,836.32
Farrukhabad	10,270	-	10,270	26,333.87	-	26,333.87
Etawah	13,004	963	13,967	33,286.41	2,464.99	35,751.39
Kanpur	2,282	24	2,306	4,332.65	45.65	4,378.30
Fatehpur	6,250	117	6,367	17,328.95	3,124.75	20,453.70
Allahabad	11,259	2,439	13,698	17,996.77	3,898.58	21,895.35
Jhansi	2,110	346	2,456	3,952.15	648.07	4,600.22
Jalaun	8,084	296	8,380	21,170.78	769.94	21,940.72
Hamirpur	-	406	406	-	777.42	777.42

(contd......)

TABLE XXXIX (Contd....)

1	2	3	4	5	6	7
Banda	1,756	300	2,056	2,990.29	510.86	3,501.15
Varanasi	15,257	872	16,129	32,766.07	1,872.71	34,638.78
Mirzapur	10,229	822	11,051	21,487.69	1,726.74	23,214.43
Jaunpur	9,758	-	9,758	25,071.16	-	25,071.16
Ghazipur	2,979	26	3,005	8,472.19	73.94	8,546.13
Ballia	4,706	16	4,722	15,313.32	52.06	15,365.38
Gorakhpur	10,288	176	10,464	15,667.49	268.02	15,935.51
Deoria	31,211	751	31,962	51,608.13	1,241.79	52,849.92
Basti	15,745	1,035	16,780	20,244.65	1,330.78	21,515.43
Azamgarh	7,544	499	8,043	13,299.74	879.71	14,179.45
Naini Tal	7,462	751	8,213	26,978.07	2,715.16	39,693.23
Lucknow	2,743	236	2,979	13,920.60	1,197.68	15,118.28
Unnao	2,050	608	2,658	5,151.19	1,527.76	6,678.95
Rae Bareli	1,664	594	2,258	4,312.81	1,539.55	5,852.36
Sitapur	2,828	123	2,951	5,269.04	229.16	5,598.20
Hardoi	4,377	799	5,176	8,329.93	1,520.58	9,850.51
Kheri	3,775	865	4,640	6,606.55	1,513.82	8,120.37
Faizabad	3,338	547	3,885	7,844.68	1,285.51	9,130.19
Gonda	7,226	123	7,349	9,984.45	169.95	10,154.40
Bahraich	3,521	305	3,826	5,786.84	501.27	6,288.11
Sultanpur	2,006	-	2,006	4,928.12	-	4,928.12
Pratapgarh	5,485	-	5,485	17,589.59	-	17,589.59
Bara Banki	5,260	588	5,848	12,270.99	13,717.38	15,988.37
Uttar Pradesh	4,75,888	26,975	5,02,863	20,506.00	1,162.30	21,668.30

Source: Office records Registrar, Co-operative Banks, Uttar Pradesh, Lucknow.

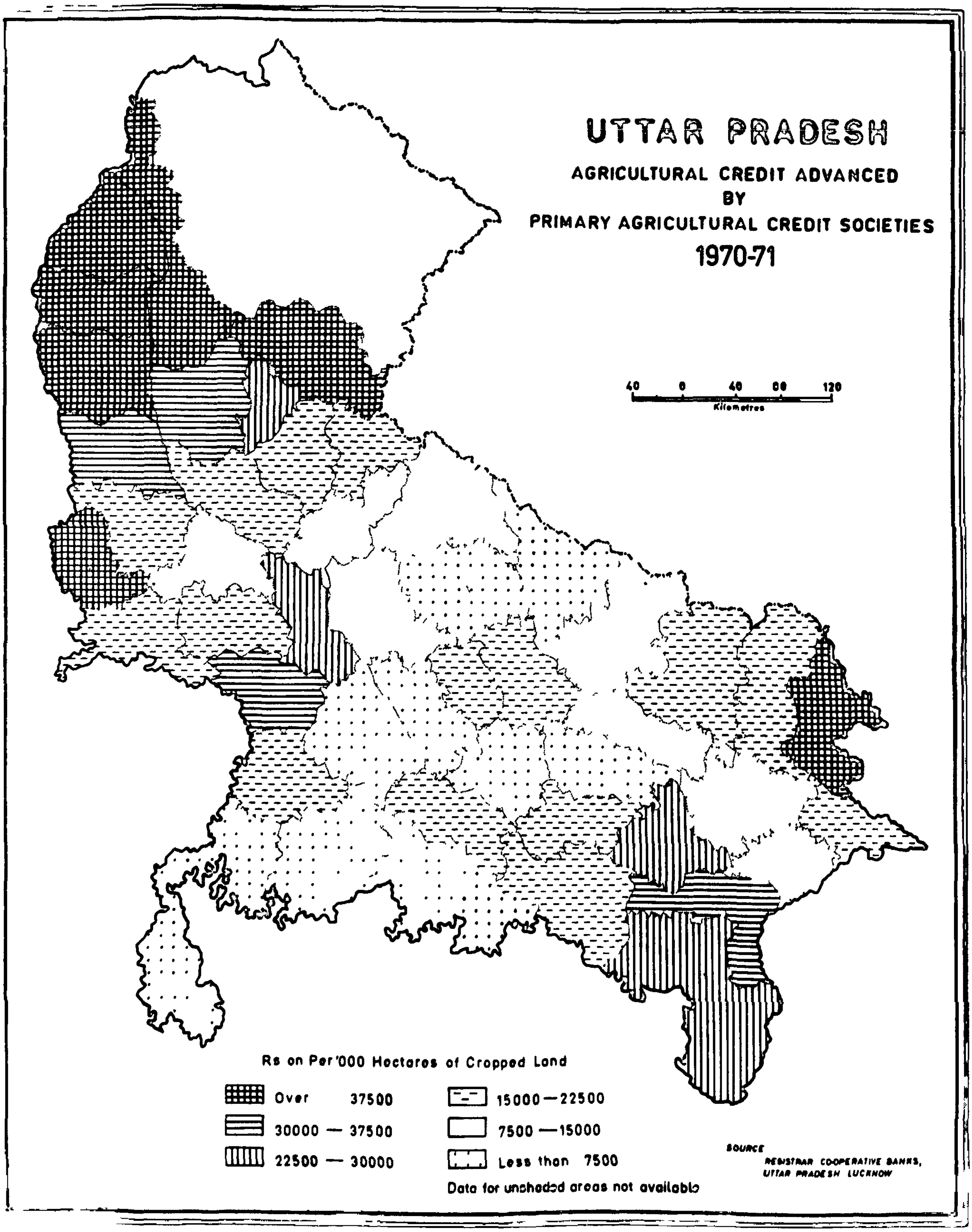
UTTAR PRADESH
AGRICULTURAL CREDIT ADVANCED
BY
PRIMARY AGRICULTURAL CREDIT SOCIETIES
1970-71
Kilometres
Rs on Per'000 Hectares of Cropped Land
Over 37500
30000 — 37500
22500 — 30000
15000—22500
7500 —15000
Less than 7500
Data for unshaded areas not available
SOURCE
REGISTRAR COOPERATIVE BANKS,
UTTAR PRADESH LUCKNOW

FIG 54

Mathura Rs.23.12 and Muzaffarnagar Rs.18.16 million respectively from the total advances of the State. The share of the farmers in other districts ranged between Rs.12 and Rs.20 million namely, Allahabad about Rs.13.68 million , Etawah Rs.13.96 million , Varanasi Rs.16.12 million , Basti 16.78 million and Bijnor Rs.19.14 million . There are four districts where farmers borrowed the credit between the range of Rs.8.00 and Rs.12.00 million , viz., Dehra Dun Rs.8.01 million , Azamgarh Rs.8.04 million , Naini Tal and Agra Rs.8.21 and Rs.8.34 million respectively. In the districts of Bareilly, Budaun and Jaunpur farmers received loans in close proximity to Rs.10.00 million . The shares of farmers in credit advances registered as Rs.11.05 million for Mirzapur, Rs.10.27 million for Aligarh and Rs.10.64 million for Gorakhpur during the corresponding year. The shares in advancement in the remaining districts recorded between the range of Rs.2.00 and Rs.8.00 million (Appendix XVIII).

To assess more precisely the distribution of loans in relation to cropped land, an attempt has been made to compute credit advances in relation to cropped land i.e. amount given to the farmers on per 1000 hectares of their cropped land. The results are produced in Table XXXIX. It is evident from the table, that the farmers of Dehra Dun, Saharanpur, Muzaffarnagar, Meerut, Bijnor, Naini Tal, Agra and Deoria districts borrowed the amount more than the range of Rs.37,500 per hectares short and medium term credit in aggrigate. The second category of districts includes the Moradabad, Bulandshahr, Etawah and Varanasi which shows the credit advance levels between the range of Rs.30,000 and Rs.37,500 (Fig.54). It is noteworthy that the above districts of the State, except Agra, Etawah and Varanasi belong to sugarcane belts of the State. Within third range of advances between Rs.22,500 and Rs.30,000 per 1000 hectres were the farmors of Farrukhabad (a potato producing district), Rampur, Jaunpur and Mirzapur districts. Besides these there is a gradual decrease in advancements in the remaining districts of the State. Thus, in the fourth category five districts of Doab, viz., Aligarh, Mathura, Mainpuri, Fatehpur and Allahabad; three from Rohilkhand region namely, Budaun, Bareilly and Pilibhit; two from Trans-Ghaghara region and four districts, viz., Lucknow, Bara Banki, Pratapgarh and Ballia of other regions show a range of credit advancements between Rs.15,000 and Rs.22,500 per 1000 hectares.

The farmers of the districts of Shahjahanpur, Kheri, Etah, Hardoi, Gonda, Faizabad, Azamgarh and Ghazipur received the advances between Rs.7,500 and Rs.15,000 per 1000 hectares. In the other remaining districts of the

State farmers received loans Rs.7,500 or less than this amount. They are namely, Bahraich, Sitapur, Kanpur, Unnao, Rae Bareli, Sultanpur, Jhansi, Hamirpur and Banda (Fig.54). Among most of them belong to the agriculturally less developed, in comparison to the rest of the State.

(d) Role of District Co-operative Banks

These banks are the basis of whole credit structure and finance the Primary Agricultural Credit Societies at the district level with respect to their short and medium term credit requirements. During 1970-71 in 54 districts of the State there were 56 banks (two each in Saharanpur and Agra districts). These banks also finance the village co-operative societies.

The Reserve Bank of India has implemented a special provision for the sanction of loans through District Co-operative Banks to the farmers, that out of the total sanctions 80 per cent will be paid by the Reserve Bank itself and of the remaining 20 per cent payments will be shared equally by the State and District Co-operative Banks respectively from their own budgets. Table XL shows a trend of functioning of these banks in the State.

(e) Districtwise Agricultural Credit Levels

The purposewise distribution of loans and their details are shown in the Appendix XIX. And Table XLI shows

TABLE XL

Assets of District Co-operative Banks in U.P. - A trend of progress

Itemwise details	1950-51	1960-61	1970-71
No. of Co-operative Banks	64	54	56
No. of branch offices	-	41	306
Memberships	24,515	53,979	35,359
Credit advancements (in thousand Rs.) (Short and Medium term)	31,437	2,92,240	5,92,297

Source: Office records Registrar, Co-operative Banks, Uttar Pradesh, Lucknow.

the aggregate short and medium term loans distributed in the districts of Uttar Pradesh by District Co-operative Banks, as well as the distribution on per 1000 hectare of cropped land. Besides these, Fig.55 is based on Table XLI to show total (short and medium) credit distribution on per 1000 hectares in each district by these banks during 1970-71.

It is evident from the Table XLI, that there are six districts in the State where farmers share in the total distribution of credit by the co-operative banks recorded highest during the corresponding year. They are namely, Bulandshahr Rs.44.62, Meerut Rs.37.33, Deoria Rs.33.10, Saharanpur Rs.27.72, Moradabad Rs.21.65 and

TABLE XLI

Districtwise credit advanced by District Co-operative Banks in U.P. -1970-71

Name of district	Distribution (in '000 Rs.)			Distribution (Rs. per 1000 hectares)		
	Short term	Medium term	Total	Short term	Medium term	Total
1	2	3	4	5	6	7
Dehra Dun	8,009	1,867	9,876	97,695.75	22,774.12	1,20,469.87
Saharanpur	27,522	199	27,721	49,745.23	359.68	50,104.90
Muzaffarnagar	19,181	953	20,134	40,129.29	1,993.80	42,123.09
Meerut	36,271	1,063	37,334	51,590.04	1,511.95	53,101.99
Bulandshahr	43,179	1,441	44,620	74,961.45	2,501.66	77,463.11
Aligarh	12,395	649	13,044	20,878.11	1,093.17	21,971.28
Mathura	17,284	1,906	19,190	42,453.06	4,681.52	47,144.58
Agra	6,965	289	7,254	15,736.30	652.94	16,389.24
Mainpuri	8,413	591	9,004	21,479.37	1,508.89	22,988.26
Etah	4,400	470	4,870	9,833.61	1,050.40	10,884.01
Bareilly	8,192	959	9,151	19,063.22	2,231.64	21,294.86
Bijnor	16,734	815	17,549	39,843.23	1,940.49	41,783.72
Budaun	8,837	370	9,207	17,147.43	717.95	17,865.86
Moradabad	21,655	-	21,655	34,217.30	-	34,217.30
Shahjahanpur	3,609	90	3,699	8,653.41	215.79	8,869.10
Pilibhit	9,605	624	10,229	34,175.65	2,220.26	36,395.91
Rampur	2,198	3,018	5,216	10,121.84	13,897.97	24,019.81
Farrukhabad	11,055	5	11,060	28,346.73	12.82	28,359.55
Etawah	11,448	1,008	12,456	29,303.50	2,580.18	31,883.68
Kanpur	1,958	300	2,258	3,717.50	569.58	4,287.08
Fatehpur	7,178	1,380	10,816	19,901.95	3,826.23	23,728.18
Allahabad	14,706	865	15,571	23,506.58	1,382.64	24,889.22
Jhansi	1,293	101	1,394	2,421.86	189.17	2,611.03
Jalaun	4,985	204	5,189	13,054.96	534.24	13,589.20
Hamirpur	3,412	818	4,230	6,533.44	1,566.34	8,099.78
Banda	1,146	268	1,414	1,951.52	456.37	2,407.87
Varanasi	14,979	1,046	16,025	32,169.04	2,246.39	34,415.43
Mirzapur	12,157	8	12,165	25,537.76	16.80	25,554.56

Contd......

TABLE XLI (contd.....)

1	2	3	4	5	6	7
Jaunpur	10,592	130	10,722	27,213.96	334.00	27,547.96
Ghazipur	2,719	50	2,769	7,732.75	142.19	7,874.94
Ballia	4,611	25	4,636	15,004.19	81.35	15,085.54
Gorakhpur	8,694	474	9,168	13,240.01	721.85	13,961.86
Deoria	32,550	554	33,104	53,822.20	916.05	54,738.25
Basti	15,694	1,018	16,712	20,179.08	1,308.92	21,488.00
Azamgarh	6,825	635	7,460	12,032.17	1,119.47	13,142.64
Naini Tal	6,618	938	7,556	23,926.67	3,391.23	27,317.90
Lucknow	2,168	236	2,404	11,002.50	1,197.68	12,200.18
Unnao	1,867	887	2,754	4,691.35	2,228.83	6,922.18
Rae Bareli	1,876	834	2,710	4,862.28	2,161.59	7,023.87
Sitapur	2,721	-	2,721	5,069.58	-	5,069.58
Hardoi	4,632	1,091	5,723	8,815.23	2,076.29	10,891.52
Kheri	3,932	1,145	5,077	6,881.31	2,003.84	8,885.15
Faizabad	2,881	555	3,436	6,770.68	1,304.31	8,074.99
Gonda	6,585	90	6,676	9,098.75	124.35	9,223.10
Bahraich	3,117	329	3,446	5,122.86	540.71	5,663.57
Sultanpur	2,090	58	2,148	5,134.49	142.48	5,276.57
Pratapgarh	4,368	2,554	6,922	14,007.54	8,190.30	22,197.84
Bara Banki	6,015	1,190	7,205	14,032.32	2,776.13	16,808.45
Uttar Pradesh	4,91,588	37,382	5,28,970	21,182.27	1,179.80	22,362.07

Source: Office records Registrar, Co-operative Banks, Uttar Pradesh, Lucknow.

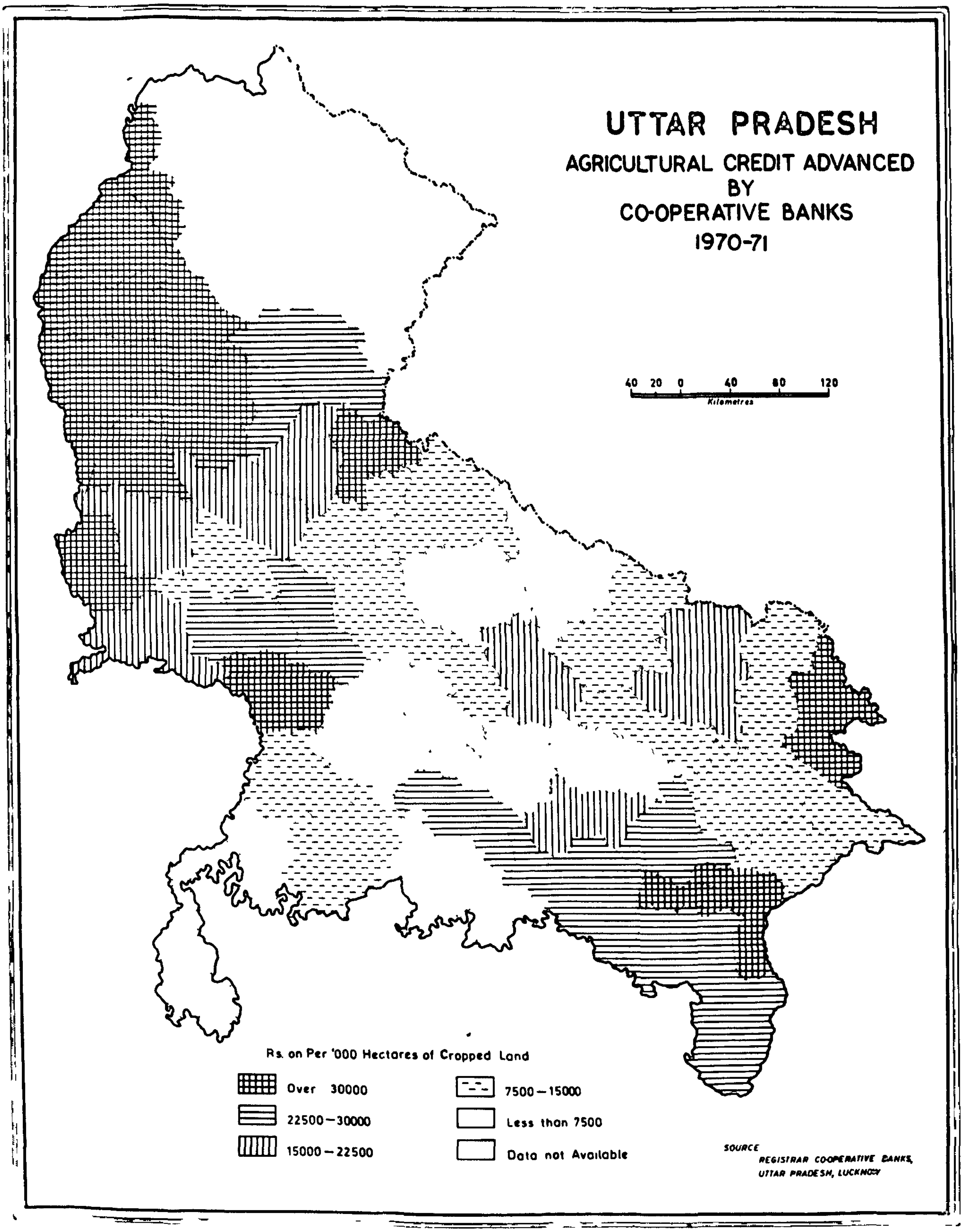
UTTAR PRADESH
AGRICULTURAL CREDIT ADVANCED
BY
CO-OPERATIVE BANKS
1970-71
40 20 0 40 80 120
Kilometres
Rs. on Per '000 Hectares of Cropped Land
Over 30000
22500—30000
15000—22500
7500—15000
Less than 7500
Data not Available
SOURCE
REGISTRAR COOPERATIVE BANKS,
UTTAR PRADESH, LUCKNOW

FIG. 55

Muzaffarnagar Rs.20.13 million . In the second category of districts where farmers received loans between the range of Rs.12.00 and Rs.20.00 million were namely Mathura, Rs.19.19, Bijnor Rs.17.55, Basti Rs.16.71, Varanasi Rs.16.02, Allahabad Rs.15.57, Aligarh Rs.13.04, Etawah Rs.12.45 and Mirzapur Rs.12.16 million . There are nine other districts which may be categorised in the third group of credit borrowers and the gross distribution ranged between Rs.8.00 and Rs.12.00 million . They are namely, Farrukhabad Rs.11.06, Kanpur Rs.10.81, Jaunpur Rs.10.72, Pilibhit Rs.10.22, Dehra Dun Rs.9.87, Budaun Rs.9.20, Gorakhpur Rs.9.16, Bareilly Rs.9.15 and Mainpuri Rs.9.00 millions respectively.

Between the range of Rs.4.00 and Rs.8.00 million agricultural credit included a set of thirteen districts representing different regions of the State. There is an another set of twelve districts which fall below the range of Rs.4.00 millions of distribution.

The Fig.55 shows the distribution of agricultural credit on per 1000 hectares of cropped land in each of the fortyeight districts of Uttar Pradesh. The figures show clearly, that out of fourteen comprising districts of Doab, six among them show a credit advancement of over Rs.30,000 namely, Saharanpur, Muzaffarnagar, Meerut, Bulandshahr, Mathura and Etawah (Table XLI). The districts representing other regions of the State where farmers received the loans of Rs.30,000 are Dehra Dun, Bijnor, Moradabad of the Rohilkhand region, Deoria and Varanasi from extreme east and south-east respectively. The second range between Rs.22,500 and Rs.30,000 possesses the districts of Naini Tal, Rampur, Mainpuri, Farrukhabad, Fatehpur, Allahabad, Jaunpur and Mirzapur. The third category of districts fall between the range of Rs.15,000 and 22,500 namely, Bareilly, Budaun, Aligarh, Agra, Basti and Bara Banki. There are thirteen districts in which the farmers received the amount of loans between the range of Rs.7,500 and Rs.15,000 per 1000 hectares. They are Etah, Shahjahanpur, Kheri, Hardoi, Jalaun, Hamirpur, Gonda, Faizabad, Gorakhpur, Azamgarh, Ghazipur and Ballia. Among the remaining eight districts the credit levels ranged less than Rs.7,500 on per 1000 hectares.

(f) <u>Distribution of Taqavi Credit</u>

The direct government loan given to the farmers is known as 'Taqavi'.[15] This is a very old practice dating from Moghul times. It is designed to meet the requirements of the farmers, for the purchase of seeds, bullocks or manure, or for repairing damages after a

15. 'Taqavi' is a Persian term, which means to strengthen.

famine or other calamity, so they may be enabled to resume cultivation. The State's Co-operative Banks were assigned to look-after the above requirements of the farmers, but in spite of all efforts in this direction about 50 per cent of the farmers are still outside the purview of co-operative membership for one reason or the other.[16] Therefore, the State Government for the adoption of high-yielding varieties programme to a satisfactory extent has initiated to distribute <u>tagavi</u> loans to the farmers, particularly to those who are not members of the co-operatives, so as to supplement their resources for the purchase of agricultural inputs, mainly fertilizers and improved seeds.

The programme of <u>tagavi</u> distribution started since 1963-64 with a meagre distribution level of Rs.38.60 million, just after the inception of intensive cultivation programme in the State, and this distribution of loan raised upto Rs.247.00 million, with an increase of about 20.4 per cent per annum till 1970-71. However, during this period there were serious apprehensions about its utility and infringement with the co-operative and other institutional credit programmes.

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16. The Government of Uttar Pradesh, <u>Evaluation of the Programme of Distribution of Tagavi for Fertilizers and Seeds by the Agriculture Department During 1967-68 and 1968-69</u> (Mimeo.), Lucknow, p.2.

The total quantum of tagavi distributed among the farmers since 1963-64 by the State Department of Agriculture for the purchase of fertilizers together with the level of fertilizers distribution both in the forms of cash and kind besides technical guidance is shown in the Table XLII. It is apparent from the figures produced in the table that the distribution of tagavi had a definite bearing for promoting fertiliser consumption

TABLE XLII

Taqavi credit advanced for fertilizer in U.P.- A trend of progress

Year	Taqavi credit for fertilizer (in million Rs.)	Distribution of fertilizer (in million tonnes)	
		By Agricultural Supply Organisation	By All other agencies
1963-64	38.60	2.20 (28.57)	7.70
1964-65	49.40	3.90 (39.79)	9.80
1965-66	48.00	4.00 (42.55)	9.40
1966-67	59.10	4.10 (48.23)	8.50
1967-68	114.40	13.60 (74.72)	18.20
1968-69	182.00	17.20 (50.88)	33.80
1969-70	231.80	18.60 (40.43)	46.00
1970-71	247.00	15.80 (62.69)	25.20

Note: Figures in parenthesises are percentages to the distribution by all other agencies.

Source: Office records Directorate of Agriculture, U.P., Lucknow.

in the State, particularly from 1967-68 onwards when an increased credits of tagavi were provided through Agricultural Supply Organisation which renders its services to the farmers.

Table XLIII shows the allocation of tagavi credit in each of the 48 districts of the State and its distribution on per 1000 hectares of cropped land during 1970-71. It is clear from the table, that the farmers of the districts namely, Gorakhpur, Aligarh, Meerut, Basti and Bulandshahr received the highest amount of credit being over Rs.1 million for the purchase of fertilizers, and seeds. The second range of distribution i.e., Rs.0.60 and Rs.0.85 million , it comprises thirteen districts of the State, viz., Kanpur, Etah, Saharanpur, Agra, Faizabad, Gonda, Allahabad, Mainpuri, Moradabad, Budaun, Muzaffarnagar, Farrukhabad and Deoria. In the districts of Sitapur, Rae Bareli, Shahjahanpur, Hardoi, Sultanpur, Jaunpur, Jalaun, Bareilly, Rampur, Ballia, Varanasi, Azamgarh, Bara Banki, Bahraich, Mathura, Bijnor and Etawah farmers received tagavi credit between the range of Rs.0.30 and Rs.0.60 million . Among the remaining districts farmers shared the loans below the range of Rs.0.30 million (Table XLIII).

The Fig.56 shows the distribution of tagavi credit in relation to cropped land i.e., the amount of

TABLE XLIII

Districtwise Taqavi credit advanced by the State Agriculture Department in U.P.- 1970-71

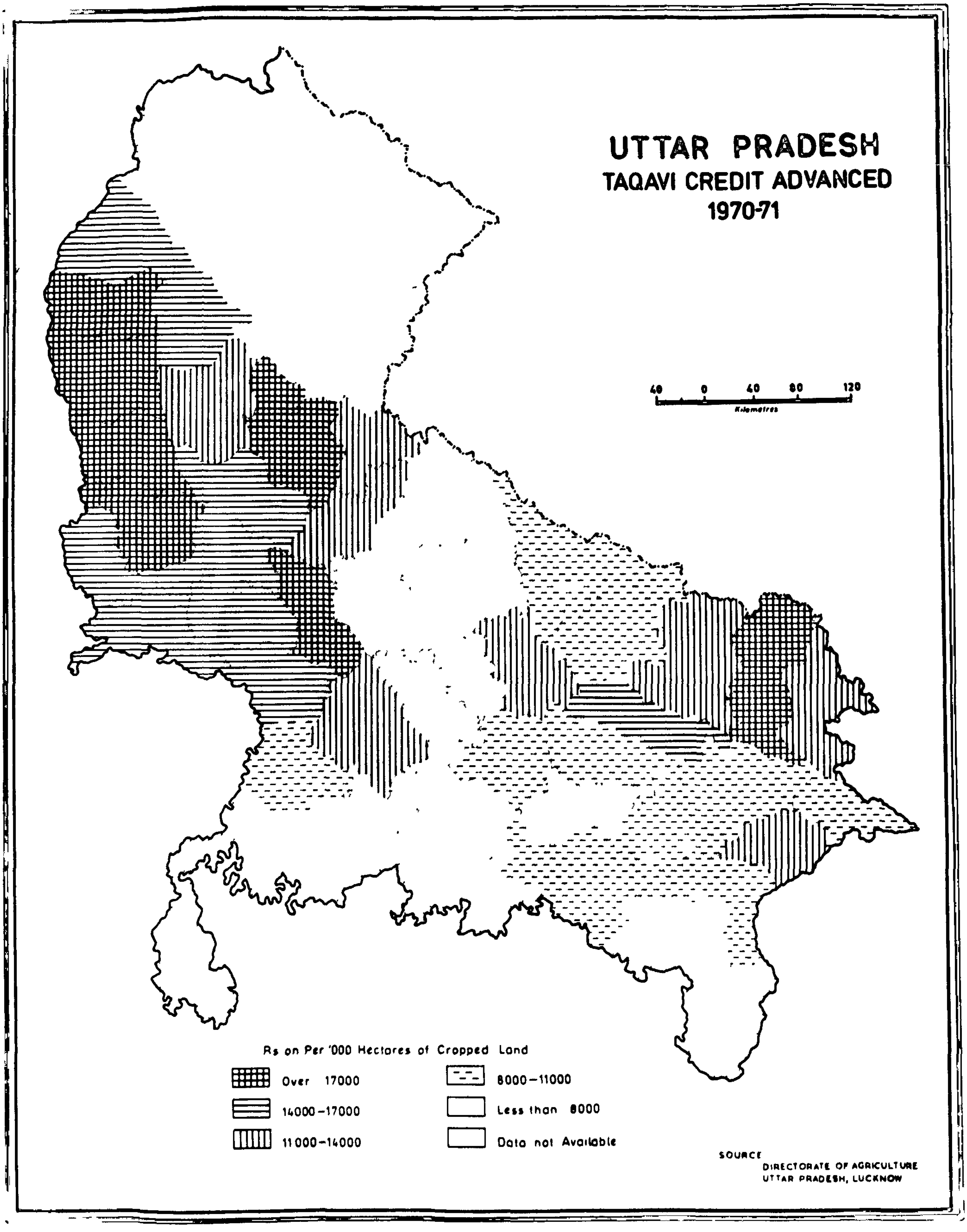
Name of district	Distribution (in '000 Rs.)	Distribution (Rs. per 1000 ha.)
1	2	3
Dehra Dun	400	4,879.29
Saharanpur	6,100	11,025.57
Muzaffarnagar	8,250	17,260.13
Meerut	10,900	18,504.00
Bulandshahr	10,350	17,968.25
Aligarh	13,200	22,234.05
Mathura	5,051	12,406.29
Agra	6,600	14,911.64
Mainpuri	6,512	16,625.90
Etah	6,059	13,541.32
Bareilly	4,240	19,032.00
Bijnor	5,169	12,307.26
Budaun	7,000	13,582.89
Moradabad	6,667	10,534.59
Shahjahanpur	3,400	8,152.28
Pilibhit	2,359	8,393.58
Rampur	4,318	19,884.50
Farrukhabad	8,082	20,723.50
Etawah	5,650	14,487.93
Kanpur	6,031	11,450.58
Fatehpur	2,551	7,072.98
Allahabad	6,366	10,175.63
Jhansi	2,661	4,984.21
Jalaun	4,000	10,475.39
Hamirpur	1,452	2,780.35

(contd.....)

TABLE XLIII (Contd.....)

1	2	3
Banda	1,515	2,579.89
Varanasi	4,475	9,610.55
Mirzapur	1,644	3,453.49
Jaunpur	4,000	10,277.17
Ghazipur	2,500	12,482.18
Ballia	4,389	8,135.00
Gorakhpur	14,296	21,771.24
Deoria	8,200	13,558.89
Basti	10,784	13,865.88
Azamgarh	4,620	8,144.85
Naini Tal	841	2,892.00
Lucknow	1,770	8,982.67
Unnao	2,850	7,161.41
Rae Bareli	3,125	8,099.48
Sitapur	3,104	5,783.27
Hardoi	3,565	6,784.60
Kheri	2,661	4,656.96
Faizabad	6,200	14,570.71
Gonda	6,388	8,798.92
Bahraich	5,000	8,217.61
Sultanpur	3,800	9,335.43
Pratapgarh	2,050	6,574.05
Bara Banki	4,750	11,081.22
Uttar Pradesh	2,47,000	10,643.27

Source: Office records Directorate of Agriculture, Uttar Pradesh, Lucknow.



UTTAR PRADESH
TAQAVI CREDIT ADVANCED
1970-71
40 0 40 80 120
Kilometres
Rs on Per '000 Hectares of Cropped Land
Over 17000
14000-17000
11000-14000
8000-11000
Less than 8000
Data not Available
SOURCE
DIRECTORATE OF AGRICULTURE
UTTAR PRADESH, LUCKNOW

FIG. 56

loan received by the farmers on 1000 hectares of their cultivable land. The farmers of five districts namely, Aligarh, Bulandshahr, Meerut, Muzaffarnagar and Farrukhabad received the amounts of loan above Rs.17,000 per 1000 hectares. The second range of advances comprises the districts of Saharanpur, Agra, Mathura, Etah, Mainpuri and Etawah of the Doab region and two Bijnor and Budaun of Rohilkhand region and Faizabad representing the eastern region where the farmers borrowed the credit between the range of Rs.14,000 and Rs.17,000. There is another category of advances in which the share of farmers computed between Rs.11,000 and Rs.14,000 per 1000 hectares, which comprises the districts of Moradabad, Kanpur, Bara Banki, Basti, Deoria, Ghazipur, Pilibhit and Shahjahanpur. Among them Moradabad, Pilibhit and Shahjahanpur belong to the Rohilkhand region, Kanpur lies in Doab, Basti and Deoria represent Trans-Ghaghara region, Bara Banki and Ghazipur are from central and eastern regions respectively of the State. The districts of Bahraich, Gonda, Rae Bareli, Sultanpur, Jaunpur, Azamgarh, Ballia and Allahabad are categorised where farmers shared the loans between the range of Rs.8,000 and Rs.11,000 per 1000 hectares. Among the other remaining districts the credit advances recorded less than Rs.8,000 per 1000 hectares (Fig.56).

CHAPTER X

DETERMINANTS OF CROPS PRODUCTIVITY

The study of input and output relationship was undertaken with the help of mathematical techniques in order to determine the relationship amongst a number of factors which may cause variations in the productivity spatially. In an effort to discover variations in productivity, a series of 12 independent input variables were selected. The values of the 12 variables are listed in Appendix XX, were claculated for each of the forty-eight districts of Uttar Pradesh for the year 1970-71.

A. Nature of the Variables

In order to determine the significance of variable 1 (output) the values of productivity indices for the year 1970-71 obtained through the four productivity evaluating methods e.g., Yang's Crop Yield Index, Standard Nutrition Unit, Output per Hectare (Rs.) and Output per Agricultural Worker (Rs.) for forty-eight districts of Uttar Pradesh the Factor Analysis was performed to decide the ranking of individual productivity method. The factor matrix of the analysis is given in Table XLIV.

TABLE XLIV

Significance of indivisual productivity index - 1970-71

Factor Matrix

Variables (Productivity evaluating method)	Factor F_1
Yang's Crop Yield Index	0.38848
Standard Nutrition Unit	0.95338
Output per Hectare (Rs.)	0.69956
Output per Agricultural Worker (Rs.)	0.93307

It is evident from Table XLIV that among the individual ranks of productivity evaluating methods analysed, Standard Nutrition Unit' output per hectare (method second) gives highest significant value being a coefficient of 0.95338 in first factor F_1 and this confirms the significance of the method. The fourth method output per agricultural worker (Rs.) follows the second order with the coefficient of 0.93307 in F_1. Following the results of this factor analysis the values of Standard Nutrition Unit per 1000 hectares of cropped land were incorporated as an output variable in each of the forty-eight districts during 1970-71 for further statistical tests of input and output analysis. The variables 2 to 5 of Table XLV stand as the resource inputs relating to irrigation, viz., canal, tube-well, by other sources and proportion of area irrigated more than once. In the 5th column of the table, data relate to the production of food crop area planted under high-yielding varieties. Variables 7 and 8 relate to inputs of fertiliser and compost manure; variable 9th relates to agricultural work force, and that can further be classified itno two different categories, that of quantity and quality. As regards to quantity, the statistical informations of actual number of persons employed in various agricultural operations is not readily available from the census. In the absence of very accurate information these figures may suffice our purpose for the present analysis. Information about animal power in 10th column of the table relates to total population of bullocks (over 3 years of age). The number was divided by the total cropped area of the respective district to get the number of bullocks per 1000 hectares. The columns 11th and 12th relate to the availability of mechanically deriven machines e.g., number of tractors (in terms of horsepower units)[1] and

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1. Assuming 1 tractor is equal to 30 horsepower units, Qouted from <u>Agro-Industries in Maharashtra Problems and Prospects</u>, Maharashtra Economic Development Council, Bombay, 1970.

TABLE XLV

The variables 1970-71

Variable	Specification	Units	Mean	Standard Deviation	Source
Food Crop Productivity	Available S.N.U. per 1000 ha.	Nos.	174.39	159.24	Computed by writer
Irrigation by canals	Ratio to the Net Irrigated Area	Per cent	39.89	26.83	Bulletin of Agricultural Statistics for U.P. 1970-71
Irrigation by Tube-wells	-do-	-do-	25.81	17.47	-do-
Irrigation by other Sources	-do-	-do-	32.74	20.65	-do-
Area irrigated more than once	Ratio to the Total Cropped Area	-do-	15.17	12.74	-do-
Area under High-Yielding Varieties	-do-	-do-	34.98	12.01	Directorate of Agriculture, U.P.
Fertilizers (NPK)	Amount per hectare TCA	Kg.	17.69	9.05	-do-
Compost Manure	Amount per 1000 ha. TCA	Tonnes	34.01	34.57	-do-
Agricultural Workers	Farmers and agricultural labourers per 1000 ha. TCA	Nos.	921.65	232.23	Census of India 1971
Animal Power	Bullocks per 1000 ha. TCA	Nos.	596.20	241.68	Department of Agricultural Census, U.P.
Tractor Power	Horsepower units per 1000 ha. TCA	Nos.	56.32	84.31	-do-
Other Power Appliances	Pumping Set and Thresher per 1000 ha. TCA	Nos.	20.10	23.41	-do-
Agricultural Credit	Advanced by Co-operative Banks, Primary Agricultural Credit Societies and Agriculture Department (Taqavi Credit) per 1000 TCA	Rs.	61,360.95	45,460.34	Registrar Co-operative Bankes, and Directorate of Agriculture, U.P.

other power appliances like, pumping sets (both diesel and electric) and threshers (for wheat, rice and other crops) respectively per 1000 hectares. The last column (13th) of the table relates to the agricultural credit advanced (in aggregate) by the three major sources of agricultural finance to the farmers in the State, viz., Primary Agricultural Credit Societies, Co-operative Banks and the Taqavi Credit distributed by the Agriculture Department in relation to cropped land i.e. credit (Rs.) advanced per 1000 hectares.

B. Factor Analysis

In order to establish cause and effect type relationship between output variable (productivity) and input factors, it was essential to identify the relevant factors through Factor Analysis. This analysis avoides a certain number of problems which are inherent in conventional studies, and further reduces the computational efforts involved in trials of different combinations for identifying the most significant relationship amongst the various feasible combinations. In contrast to the Regression Analysis, factor analysis deals directly with correlative dependents by arranging variables into independent linear combinations and permits any indicator to be treated as a dependent variable of a small set of common components. The procedure encourages an expansion of the variable set.

In the present work the relevant factors and their group combinations having significant reliability have been identified through factor analysis. This has lessened the likelyhood of eroneous policy recommendations which may not be adopted inadvertently. There are certain important reasons for performing the factor analysis before establishing functional relationship amongst the selected variables. It is argued that in cross-regional comparisons, it is desirable to identify the variables on the basis of their past adherence to certain norms by the farmers who not only desire to select the most suitable set or combination of available resources but also interact with other parameters which may not be quantified but do exert their influence. This calls for identification of all such variables which have an influence on the dependent variables in group.

By performing factor analysis, we are able to look at sets of complementary and thus collinear inputs or at "packages" of inputs, and may include a wider range of variables of relevance for production function. Here it may be hypothesised, that a set of twelve variables considered influence productivity function, treating productivity function as dependent on twelve independent (inpur) factors. The productivity index of the respective district was taken to be as an effect produced by the selected twelve input variables. The data produced in Appendix XX was analysed through factor analysis package programe available as scientific sub-routin on Computer IBM 1130 system (Appendix XXI, Programme No.1). The analysis was performed taking into consideration the whole of the Uttar Pradesh as one single unit. The rotated factor matrix of the variables selected for the year 1970-71 has been given in Table XLVI which indicates a "package of variables" having significant inter-cohision. The first factor F_1 accounts for 44.12 per cent variance in the total variables set. The variables show high positive co-efficients loading for fertilizers (0.88), area under HYV (0.76), crop productivity index (0.76) and tractor power (0.74). Second factor F_2 has yielded no significant interpretation for the analysis. However, F_3 explains the inter-relationship amongst the variables of other power appliances with a positive loading of 0.91, use of compost manure 0.86, area irrigated more than once 0.77 and agricultural credit 0.76. The significance of the rest of the variables does not emerge owing to great variations of the district level statistics.

TABLE XLVI

Determinants of productivity in U.P. - 1970-71
The Rotated Factor Matrix

Variables	Factors F_1	F_2	F_3	R^2
Food crop productivity	0.760	0.295	0.256	0.758
Irrigation by canals	-0.098	0.522	-0.008	0.968
Irrigation by tube-wells	0.339	0.200	0.011	0.916
Irrigation by other sources	-0.122	-0.819	0.036	0.793
Area irrigated more than once	0.460	0.163	0.772	0.849
Area under HYV	0.765	-0.275	0.166	0.737
Fertilizers (NPK)	0.883	-0.165	0.185	0.891
Compost manure	0.080	0.044	0.869	0.765
Agricultural workers	0.084	-0.886	-0.126	0.810
Animal power	-0.093	-0.852	-0.101	0.771
Tractor power	0.741	0.387	0.181	0.737
Other power appliances	0.075	-0.044	0.913	0.842
Agricultural credit	0.339	0.158	0.765	0.748
Variance explained %	44.12	28.69	17.14	
Cumulative variance explained %	44.12	72.81	89.95	

The aggregated analysis of variables selected reveals that a reasonably good relationship may exist between three critical factors as identified (Table XLVI).

Further, non-occurrence of other variables in the consolidated analysis made it necessary to analyse the variables in different productivity groups in order to study the inter-action of the remaining variables on regional basis. These productivity regions demarcated on the basis of Standard Nutrition Unit output as shown in Fig.38. The SNU index used for the analysis relates to the year 1970-71 and for production figures of 13 food crops.[2] Thus the productivity regions were seperately analysed considering the variables selected. The rationale for analysing the cause and effect of variables in different groups (productivity regions) lies with the fact that different regions have different packages of variables which may have a direct effect on the agricultural productivity, and was tested in different combinations.

(a) <u>Determinants of productivity in very high productivity regions</u>

The rotated factor matrix of the variables is given in Table XLVII which yielded three significant

2. Data from Table XIV of Chapter VII.

TABLE XLVII

Determinants of productivity in very high productivity region - 1970-71

The Rotated Factor Matrix

Variables	Factors		
	F_1	F_2	R^2
Food crop productivity	0.688	0.724	0.999
Irrigation by canals	0.973	0.230	0.999
Irrigation by Tube-wells	-0.685	-0.728	0.999
Irrigation by other sources	-0.997	0.076	0.999
Area irrigated more than once	-0.418	0.907	0.999
Area under HYV	0.040	0.999	0.999
Fertilizers (NPK)	0.206	0.977	0.999
Compost manure	-0.989	-0.144	0.999
Agricultural workers	0.518	0.855	0.999
Animal power	-0.718	-0.695	0.999
Tractor power	0.906	0.421	0.999
Other power appliances	0.937	0.347	0.999
Agricultural credit	-0.876	0.481	0.999
Variance explained %	69.40	30.60	
Cumulative variance explained %	69.42	100.00	

factors, First factor F_1 accounts 69.40 per cent variance from the total variable set, which comprises the variables of irrigation by canals, use of tractor power, other power appliances. The loadings or coefficients which describe this factor indicate a strongly positive relationship with the values of variables e.g. irrigation by canals 0.973 use of other power appliances and tractor power 0.937 and 0.906 respectively. The second factor F_2 relates to the package of variables of lesser significance with a variance of 30.6 per cent of area irrigated more than once, area under HYV fertilizer and deployment of agricultural work force. This leads to an inference that in this region and modern scientific methods are involved alongwith cheap and easily available irrigation facilities by the presence of canals network.

(b) <u>Determinants of productivity in high productivity regions</u>

The variables identified in high productivity regions with a total variance of 47.76 per cent and with F_1 are animal power, irrigation by other sources, deployment of agricultural work force and irrigation by tube-wells Table XLVIII. The second factor F_2 is innovation base and accounts for 29 per cent of the total variance. It registers a set of variables as area irrigated more than

TABLE XLVIII

Determinants of productivity in high productivity region - 1970-71

The Rotated Factor Matrix

Variables	Factors F_1	F_2	F_3	R^2
Food crop productivity	0.126	-0.043	0.963	0.945
Irrigation by canals	-0.962	0.151	-0.222	0.999
Irrigation by Tube-wells	0.743	-0.516	0.420	0.996
Irrigation by other sources	0.905	0.398	-0.120	0.995
Area irrigated more than once	-0.161	0.985	-0.325	0.998
Area under HYV	0.032	0.959	-0.126	0.938
Fertilizers (NPK)	0.370	0.899	0.195	0.985
Compost manure	-0.413	-0.043	0.848	0.892
Agricultural workers	0.900	0.264	-0.304	0.974
Animal power	0.956	0.029	0.282	0.996
Tractor power	-0.680	-0.336	0.336	0.689
Other power appliances	0.265	0.417	0.716	0.758
Agricultural credit	0.458	0.793	0.400	0.999
Variance explained %	47.76	29.04	23.20	
Cumulative variance explained %	47.76	76.80	100.00	

once, area under HYV fertilizer use and advancement of credit. The sound foundations of these variables lead to ascertain the causes of higher productivity. The third factor F_3 account 23.2 per cent of the total variance with the variables set of productivity index itself, use of compost manure and other power appliances.

(c) <u>Determinants of productivity in medium productivity regions</u>

The independent variables identified in the medium productivity regions account for 43.38 per cent of the total variance with high positive loadings of variables as, as set ratio of area irrigated more than once (0.94), agricultural credit (0.92), use of other power appliances (0.91) and use of compost manure (0.83). Thus, one can observe that there is a reinforcing relationship between credit service availability and use of power appliances for achieving higher productivity. The second and third factors F_2 and F_3 do not yield any significant variable except agricultural work force and proportion of irrigation by other sources with factor loadings of 0.87 and 0.93 respectively (Table XLIX).

(d) <u>Determinants of productivity in low productivity regions</u>

In the low productivity regions factor one F_1 does not yield any significant coefficient or loadings of

TABLE XLIX

Determinants of productivity in medium productivity region - 1970-71

The Rotated Factor Matrix

Variables	Factors F_1	F_2	R^2
Food crop productivity	0.161	0.140	0.857
Irrigation by canals	0.325	0.466	0.961
Irrigation by Tube-wells	-0.561	-0.761	0.923
Irrigation by other sources	0.209	0.250	0.991
Area irrigated more than once	0.946	0.014	0.945
Area under HYV	-0.149	-0.946	0.934
Fertilizers (NPK)	-0.125	-0.468	0.932
Compost manure	0.831	0.065	0.971
Agricultural workers	-0.220	0.879	0.912
Animal power	0.442	0.644	0.947
Tractor power	0.185	-0.287	0.804
Other power appliances	0.918	0.281	0.961
Agricultural credit	0.921	0.013	0.857
Variance explained %	43.38	27.73	
Cumulative variance explained %	43.38	71.11	

variables. In second factor F_2 the total variance accounted 26.62 per cent with a set of variables tractor power, agricultural credit and compost manure with their positive loadings of 0.93, 0.78 and 0.75 respectively. Evidently, the use of tractors is sufficiently responsible as the determinant of productivity spatially. Next in importance is the advancement of agricultural credit (Table L).

(e) Determinants of productivity in very low productivity regions

The dimension of F_1 accounts for 43.06 per cent of the total variance reflects the total influence of variables like area irrigated more than once and area planted under HYV, with their positive loadings of 0.90 and 0.77 respectively in the variables set. The second factor F_2 accounted 29.83 per cent of the total variance and shows the prepoderance of variables agricultural work force and use of animal power in agricultural systems. In contrast, the negative loading highlight the fact that irrigation by canal (-0.84) tend to be segregated from productivity spatially in these regions (Table LI).

C. Choice of a Function

The package of variables influencing the productivity spatially were thus identified for the whole

TABLE L

Determinants of productivity in low productivity region - 1970-71

The Rotated Factor Matrix

Variables	Factors F_1	Factors F_2	R^2
Food crop productivity	-0.041	-0.217	0.870
Irrigation by canals	0.291	0.223	0.938
Irrigation by Tube-wells	0.222	0.032	0.696
Irrigation by other sources	-0.417	-0.403	0.783
Area irrigated more than once	-0.272	0.292	0.672
Area under HYV	-0.869	0.348	0.905
Fertilizers (NPK)	-0.970	0.033	0.954
Compost manure	-0.113	0.754	0.720
Agricultural workers	-0.753	-0.457	0.867
Animal power	-0.754	-0.474	0.908
Tractor power	0.183	0.930	0.950
Other power appliances	-0.414	0.307	0.762
Agricultural credit	-0.038	0.781	0.724
Variance explained %	39.88	26.62	
Cumulative variance explained %	39.88	66.50	

TABLE LI

Determinants of productivity in very low productivity region - 1970-71

The Rotated Factor Matrix

Variables	Factors F_1	Factors F_2	R^2
Food crop productivity	0.632	0.170	0.688
Irrigation by canals	0.004	-0.843	0.959
Irrigation by Tube-wells	0.030	0.201	0.762
Irrigation by other sources	0.011	0.873	0.783
Area irrigated more than once	0.906	-0.097	0.839
Area under HYV	0.771	0.297	0.868
Fertilizers (NPK)	0.699	0.304	0.830
Compost manure	0.080	0.049	0.860
Agricultural workers	0.326	0.791	0.816
Animal power	-0.074	0.732	0.816
Tractor power	-0.017	-0.447	0.822
Other power appliances	0.486	-0.015	0.802
Agricultural credit	0.220	-0.162	0.601
Variance explained %	43.06	29.83	
Cumulative variance explained %	43.06	72.89	

of forty-eight districts of Uttar Pradesh considering them in one single unit as well in each productivity region ranked very high, high, medium, low and very low call for establishment of a mathematical relationship in the form of a single equation to explain the effect of input variables over productivity index. The relevance of Cobb-Douglas type of function in a number of studies has found sound validity due to its various advantages. It gives a single equation, when we try to test the sensitivity of the equation in determining the effect of agriculturally related independent variables (inputs) over the dependent variable production/productivity (output).

Therefore, in developing a mathematical relationship through statistical analysis, related to production/productivity (output) and inputs, 'Multiple Regression' analysis leading to the development of a Cobb-Douglas type of function has been adopted. This function is basically a logarithmic linear relationship between the objective function of production/productivity versus the number of inputs.

Non-occurrence of a particular variable in a certain group pertaining to a specific region, does not mean, that a certain variable will not interact in other groups, but this may be due to the existance of high level variances of input facility in other regions. The factor analysis of different productivity regions facilitated to identify the most relevant packages of input variables rather than taking individual variable in isolation. On the basis of selected groups identified packages and sets of variables having degree of significance in each group of data, multiple regression technique was applied to establish a Cobb-Douglas type of function.

Under various groups of productivity the combination of variables used for Cobb-Douglas function analysis are given in Table LII. For the development of function, the values of each input variable were converted into logarithm for the analysis for each productivity region to accomodate 'n' variables.

The function can be written as:

$$Y_1 = A\, x^b\, x_2^c\, x_3^d \text{ ------ } x_n^y$$

Taking logarithm of the above equation, the same equation takes the form of a linear equation, and can be written as:

$$\log Y_1 = \log A + b \log x_2 + C \log x_3 \text{ ---- } x_n$$

TABLE LII

Input variables included for multiple regression analysis in each food crop productivity region of U.P. - 1970-71

Productivity Region	Variables included in the combination set		Factors F_1	F_2	F_3
1	2	3	4	5	6
Very High	Combination I	X_2	0.973	-	-
		X_{12}	0.937	-	-
		X_{11}	0.906	-	-
	Combination II	X_6	-	0.999	-
		X_7	-	0.977	-
		X_5	-	0.907	-
		X_9	-	0.855	-
High	Combination I	X_{10}	0.956	-	-
		X_4	0.905	-	-
		X_9	0.900	-	-
		X_3	0.743	-	-
	Combination II	X_5	-	0.985	-
		X_6	-	0.959	-
		X_7	-	0.899	-
		X_{13}	-	0.793	-
	Combination III	X_8	-	-	0.848
		X_{12}	-	-	0.716

(contd....)

TABLE LII (Contd.....)

1	2	3	4	5	6
Medium	Combination I	X_5	0.946	-	-
		X_{13}	0.921	-	-
		X_{12}	0.918	-	-
		X_8	0.831	-	-
Low	Combination I	X_{11}	-	0.930	-
		X_{13}	-	0.781	-
		X_8	-	0.754	-
Very Low	Combination I	X_5	0.906	-	-
		X_6	0.771	-	-
		X_7	0.699	-	-
	Combination II	X_4	-	0.873	-
		X_9	-	0.791	-
		X_{10}	-	0.723	-
Uttar Pradesh (48, districts)	Combination I	X_7	0.883	-	-
		X_6	0.765	-	-
		X_{11}	0.741	-	-
	Combination II	X_{12}	-	-	0.913
		X_8	-	-	0.869
		X_5	-	-	0.772
		X_{13}	-	-	0.765

Note: X_2 = Irrigation by canals, X_3 = Irrigation by tubewells X_4 = Irrigation by other sources, X_5= Area Irrigated more than once, X_6 = Area under HYV, X_7 = Fertilizers (NPK), X_8 = Compost Mannures, X_9 = Agricultural Worker, X_{10} = Animal Power, X_{11} = Tractor Power, X_{12} = Other Power Appliances, X_{13}= Agricultural Credit.

The most important advantages of this type of function are two-fold. Firstly, the coefficients of function are equal to the elasticities of production/productivity with respect to different inputs. In other words b, c, d, ------y in the above equation are the elasticities of production/productivity related to inputs, which can symbolically be defined as input variables in the form of X_2, X_3, X_4-------X_n respectively. Whereas, Y_1 defines the output side, which is dependent on input factors. Secondly, the function makes it possible for the principle of diminishing returns to operate within the scale.

A generalised 'multiple regression' programme on SSP[3] was adopted and computation performed on computer IBM 1130 (Appendix XXI, Programme 2).

The methodology of multiple regression first be explained by selecting a set of 2 and then 3 independent variables. Suppose, for example, we are interested in predicting Y_1 a dependent output oriented variable and X_2 and X_3 be the independent variables related to inputs.

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3. Scientific Sub-routine Programme.

Assume that the true underlying relationship is of the form

$$\text{average value of } y = B_0 + B_1 x_2 + B_2 x_2$$

If we denote the estimates of the B_i by b_i, the least squares estimate is $y = b_0 + b_1 x_1$, where b_1 and b_2 are found from the following set of equation:

$$\sum_{i=1}^{n}(y_i - \bar{y})(x_{1i} - \bar{x}_1) = b_1 \sum_{i=1}^{n}(x_1 - \bar{x}_1)^2 + b_2 (x_1 - \bar{x}_1)(x_{2i} - \bar{x}_2)$$

$$\sum_{i=1}^{n}(y_i - \bar{y})(x_{2i} - \bar{x}_2) = b_1 \sum_{i=1}^{n}(x_{1i} - \bar{x}_1)(x_{2i} - \bar{x}_2) + b_2 \sum_{i=1}^{n}(x_{2i} - \bar{x}_2)^2$$

$$b_0 = \bar{y} - b_1 \bar{x}_1 - b_2 \bar{x}_2$$

These equations are known as normal equations and can be solved by solving first for b_1 in terms of b_2 and substituting this expression for b_1 in the second, or by any other method. In general, we might consider a regression equation of the sort

$$\text{average value of } y = B_0 + B_1 x_1 + B_2 x_2 + \ldots B_k x_k$$

with estimates

$$\bar{y} = b_0 + b_1 x_1 + b_2 x_2 + \ldots . + b_k x_k$$

where b_1, b_2, ..., b_k are found by the solution of a set of k simultaneous equations in k unknowns. For $k = 2$ and 3, detailed instructions are given as follows: computational scheme for solving the normal equations as formulated above

$$\bar{y} = b_o + b_1 x_1 + b_2 x_2$$

The normal equations presented in the preceding paragraphs are of the form

$$a_{11}\, b_1 + a_{12}\, b_2 + c_1 \;;\; a_{21}\, b_1 + a_{22}\, b_2 = c_2$$

where

$$a_{11} = \sum_{i=1}^{n} (x_{1_i} - x_1)^2 = \sum_{i=1} x_{1_i}^{\,2} - n\bar{x}_1^{\,2} = \text{-----}$$

$$a_{21} = a_{12} = \sum_{i=1}^{n} (x_{1_i} - \bar{x}_1)\,(x_{2_i} - \bar{x}_2) = \sum_{i=1}^{n} x_{1_i} x_{2_i} - n\bar{x}_1 \bar{x}_2 = \text{------}$$

$$a_{22} = \sum_{i=1}^{n} (x_{2_i} - \bar{x}_2)^2 = \sum_{i=1}^{n} x_{2_i}^{\,2} - n\bar{x}_2^{\,2} = \text{---------}$$

$$c_1 = \sum_{i=1}^{n} (x_{1_i} - \bar{x}_1)\,(y_i - \bar{y}) = \sum_{i=1}^{n} x_{1_i} y_i - n\bar{x}_1\,\bar{y} = \text{-----}$$

$$c_2 = \sum_{i=1}^{n} (x_{2_i} - \bar{x}_2)\,(y_i - \bar{y}) = \sum_{i=1}^{n} x_{2_i}\, y_i - n\bar{x}_2\, y = \text{---}$$

operation	b_1	b_2	c	check
(1)	a_{11}	a_{12}	c_1	$a_{11} + a_{12} + c_1$
(2)	a_{21}	a_{22}	c_2	$a_{21} + a_{22} + c_2$
(3)(1)repeated	u_{11}	u_{12}	u_{13}	
(4)(3)divided by a_{11}	1	v_{12}	v_{13}	
(5)(2) - v_{12}X(3)	0	u_{22}	u_{23}	
(6)(5)divided by u_{22}	0	1	v_{23}	

solution

(7) $$b_2 = V_{23}$$

(8) $$b_1 = V_{13} - V_{12}\ b_2$$

(9) $$b_o = \bar{y} - b_1 x_1 - b_2 \bar{x}_2$$

The check is started with line 3. All the operations from line 3 on are performed on the values in the check column. For each line, then, the sum of the entries in all the columns should check with the entry in the check column.

Computational scheme for solving the normal equations for 3 independent variables:

$$\bar{y} = b_o + b_1 x_1 + b_2 x_2 + b_3 x_3$$

The normal equations are of the form:

$$a_{11} b_1 + a_{12} b_2 + a_{13} b_3 = c_1$$

$$a_{21} b_1 + a_{22} b_2 + a_{23} b_3 = c_2$$

$$a_{31} b_1 + a_{32} b_2 + a_{33} b_3 = c_3$$

Where

$$a_{11} = \sum_{i=1}^{n} (x_{1_i} - \bar{x}_1)^2 = \sum_{i=1}^{n} x_{1_i}{}^2 - n\bar{x}_1{}^2 = \text{-------}$$

$$a_{21} = a_{12} = \sum_{i=1}^{n} (x_{1_i} - \bar{x}_1)(x_{2_i} - \bar{x}_2) = \sum_{i=1}^{n} x_{1_i} - x_{2_i} - n\bar{x}_1\ \bar{x}_2 = \text{------}$$

$$a_{22} = \sum_{i=1}^{n} (x_{2_i} - \bar{x}_2) = \sum_{i=1}^{n} x_{2_i}{}^2\ n\bar{x}_2{}^2 = \text{---------}$$

$$a_{13} = a_{31} = \sum_{i=1}^{n} (x_{1_i} - \bar{x}_1)(x_{3_i} - \bar{x}_3) = \sum_{i=1}^{n} x_{1_i}\ x_{3_i} - n\bar{x}_1\ \bar{x}_3 = \text{------}$$

$$a_{23} = \sum_{i=1}^{n}(x_{2_i} - \bar{x}_2)(x_{3_i} - \bar{x}_3) = \sum_{i=1}^{n} x_{2_i}\, x_{3_i} - n\bar{x}_2\,\bar{x}_3 = \text{------}$$

$$a_{33} = \sum_{i=1}^{n}(x_{3_i} - \bar{x}_3)^2 = \sum_{i=1}^{n} x_{3_i}^{\ 2} - n\bar{x}_3^{\ 2} = \text{-------}$$

$$c_1 = \sum_{i=1}^{n}(x_{1_i} - \bar{x}_1)(y_i - \bar{y}) = \sum_{i=1}^{n} x_{1_i}\, y_i - nx_1\,\bar{y} = \text{-------}$$

$$c_2 = \sum_{i=1}^{n}(x_{2_i} - \bar{x}_2)(y_i - \bar{y}) = \sum_{i=1}^{n} x_{2_i}\, y_i - n\bar{x}_2\,\bar{y} = \text{-------}$$

$$c_3 = \sum_{i=1}^{n}(x_{3_i} - \bar{x}_3)(y_i - \bar{y}) = \sum_{i=1}^{n} x_3\, y_i - n\bar{x}_3\,\bar{y} = \text{-------}$$

Operation	b_1	b_2	b_3	c	Check
(1)	a_{11}	a_{12}	a_{13}	c_1	$a_{11}+ a_{12}+ a_{13}+ c_1$
(2)	a_{21}	a_{22}	a_{23}	c_2	$a_{21}+ a_{22}+ a_{23}+ c_2$
(3)	a_{31}	a_{32}	a_{33}	c_3	$a_{31}+ a_{32}+ a_{33}+ c_3$
(4) (1)repeated	μ_{11}	μ_{12}	μ_{13}	μ_{14}	
(5) (4)divided by a_{11}	1	V_{12}	V_{13}	V_{14}	
(6) (2)- V_{12} (4)	0	μ_{22}	μ_{23}	μ_{24}	
(7) (6)divided by μ_{22}	0	1	V_{23}	V_{24}	
(8) (3)- V_{13} X (4)- V_{23}(6)	0	0	μ_{33}	μ_{34}	
(9) (8)divided by μ_{33}	0	0	1	V_{34}	

solution

(10) $b_3 = V_{34}$

(11) $b_2 = V_{24} - V_{23}\, b_3$

(12) $b_1 = V_{14} - b_3 V_{13} b_2 \;\; V_{12}$

(13) $b_o = \bar{y} - b_1\,\bar{x}_1 \;\; b_2\bar{x}_2 - b_3\bar{x}_3$

The check is started with line 4. All the operations from line 4 are performed on the values in the check column. For each line, then the sum of the entries in all the columns should check with the entry in the check column.

(a) Regression equations

The results of multiplo regressions of Y_1 on different combinations of resource inputs have been computed in logarithm values of the variables. The values of the coefficients of net regression, the coefficient of multiple regression, the standard error of estimate and of the standard errors of the regression coefficients for different productivity regions are given in Table LIII. Different combinations of the resource inputs are denoted by I to IX in the productivity regions. In combination I of the high productivity region the regression of Y_1 on X_8 and X_{12} has been taken into account, in combination II the regression on Y_1 on X_3, X_4, X_9 and X_{10} has been considered, and so on, as will be evident from Table LIII. The Cobb-Douglas type of function developed through multiple regression analysis and the values of constants for different sets of analysis takes the following forms of equation:

TA LIII

Values of coefficients in the productivity equation and measures of reliability of the equation in different productivity regions of U.P. - 1970-71

Independent variables	Symbol of coefficient	Value of coefficient in different equations with X_1 (Productivity as dependent variable) High Region Combinations I	II	III	Medium Region Combination IV	Low Region Combination V	Very Low Combinations VI	VII	Uttar Pradesh (48 districts) Combinations VIII	IX
1	2	3	4	5	6	7	8	9	10	11
Irrigation by canals X_2	B	-	-	-	-	-	-	-	-	-
Irrigation by Tube-wells X_3	C	-	-0.289	-	-	-	-	-	-	-
Irrigation by other sources X_4	D	-	-0.033	-	-	-	-	0.009	-	-
Area irrigated more than once X_5	E	-	-	0.034	-0.075	-	0.023	-	-	0.009
Area under HYV X_6	F	-	-	-0.010	-	-	0.012	-	-0.500	-
Fertilizers (NPK) X_7	G	-	-	-2.929	-	-	0.260	-	0.796	-
Compost manure X_8	H	0.257	-	-	0.420	0.085	-	-	-	0.130
Agricultural workers X_9	I	-	-1.406	-	-	-	-	1.245	-	-
Animal power X_{10}	J	-	3.056	-	0.352	-	-	-0.520	-	-
Tractor power X_{11}	K	-	-	-	-	-0.060	-	-	0.316	-
Other power appliances X_{12}	L	0.400	-	-	-0.078	-	-	-	-	0.582
Agricultural credit X_{13}	M	-	-	1.810	-0.203	-0.119	-	-	-	0.164
Constant term (in log.)		2.700	-0.194	7.373	2.82	3.677	1.678	0.513	0.046	1.455
Constant term (in real units)		501.291	1.565	23611300	668.405	4754.34	47.6519	3.25844	1.11204	28.5135
Coefficient of correlation		0.851	0.999	1.00000	0.84674	0.691	0.59448	0.69162	0.71802	0.70921
Standard Error of Estimate (S in logarithms)		0.072	0.00021	0.00017	0.13028	0.051	0.13832	0.12424	0.25049	0.25665
Standard Error of the coefficients:	B	-	-	-	-	-	-	-	-	-
	C	-	0.00099	-	-	-	-	-	-	-
	D	-	0.00083	-	-	-	-	0.06457	-	-
	E	-	-	0.00074	0.51371	-	0.09266	-	-	0.10910
	F	-	-	0.00178	-	-	0.29853	-	0.42421	-
	G	-	-	0.00373	-	-	0.20918	-	0.28410	-
	H	0.140	-	-	0.23742	0.06211	-	-	-	0.09278
	I	-	0.00263	-	-	-	-	0.39456	-	-
	J	-	0.00425	-	1.02735	-	-	0.17719	-	-
	K	-	-	-	-	0.10364	-	-	0.09789	-
	L	0.390	-	-	0.41025	-	-	-	-	0.17024
	M	-	-	0.00184	0.28628	0.09568	-	-	-	0.16845

Relationship between productivity and input variables in different productivity regions:

Productivity region			Multiple correlation
High	I.	$Y_1 = 501.291\, X_8^{0.25756}\, X_{12}^{0.40077}$	0.85151
	II.	$Y_1 = 1.56596\, X_9^{-1.40647}\, X_{10}^{3.05631}$	0.99999
	III.	$Y_1 = 23611300\, X_5^{0.03473}\, X_6^{-0.01037}\, X_7^{-2.02915}\, X_{13}^{1.81033}$	1.00000
Medium	IV.	$Y_1 = 668.405\, X_5^{-0.07541}\, X_8^{0.42056}\, X_{10}^{0.35207}\, X_{12}^{-0.07897}\, X_{13}^{-0.20369}$	0.84674
Low	V.	Relation insignificant	
	VI.	-do-	
	VII.	-do-	
Uttar Pradesh (48 districts combined)	VIII.	$Y_1 = 1.11204\, X_6^{-0.50036}\, X_7^{0.79633}\, X_{11}^{0.31679}$	0.71802
	IX.	$Y_1 = 28.5135\, X_5^{0.00902}\, X_8^{0.13090}\, X_{12}^{0.58214}\, X_{13}^{0.16421}$	0.70921

The high productivity region gives most interesting results for the combination I with very high coefficient of correlation as 0.85151, and the standard errors of regression coefficients 0.14094 and 0.39097 for the variables X_8 and X_{12} respectively. In the combination II, the coefficient of correlation accounts 0.99999, and the standard errors of regression coefficients 0.00099, 0.00083, 0.00263 and 0.00425 for the variables X_3, X_4, X_9 and X_{10} respectively. For the III combination the analysis yielded the correlation of coefficient 1.00000 with the standard errors of regression coefficients 0.00074, 0.00178, 0.00373 and 0.00184 for the variables X_5,X_6, X_7 and X_{13} (Table LIII) respectively. Whereas, the medium and low productivity regions have least significant relationships with high standard errors of regression coefficients. The analysis of all regions combined gives some significant results with combination VIII, the coefficient of correlation being 0.71802 with the standard errors of regression coefficients 0.42421, 0.28410 and 0.09789 for the variables X_6, X_7 and X_{11} respectively. For the combination IX, the coefficient of correlation is 0.70921 with the standard errors of regression coefficients 0.10910, 0.09278, 0.17024 and 0.16845 for the variables X_5, X_8, X_{12} and X_{13} respectively (Table LIII).

The above description indicates that the multiple regression analysis of combined productivity regions (Uttar Pradesh as a whole) has lesser significance than the analysis performed for each productivity region. The results furthers substantiate the earlier hypothesis, that the regional sensitivity of packages of variables have different influence in different productivity regions, but this does not mean that these packages will not have similar effects in other regions, instead it reveals the causes of variations in regional productivity spatially with the dependent variables and their interactions.

The results of this analysis may be helpful in determining the optimal combination of variables set described earlier as packages, which may be applied in other regions provided their feasibility is ascertained and may result in a higher rate of growth and optimal utilization of inputs.

The best Cobb-Douglas type of relationship taking into consideration the multiple coefficient of correlation, standard error of estimate and of standard error of coefficients, show that the influence of compost manure and use of other power applicances have positive correlation with productivity (with multiple correlation 0.85). Other relationships although have a high multiple correlation but the standard errors of regression coefficient possessing high values, make the relationship of lesser significance.

Next significant relationship is yielded by the combination IX, whereby, variables X_5, X_8 and X_{13} (Table LIII) show significant relationship. The true significant Cobb-Douglas type of relationship yielded in this analysis are of combinations I, II and IX (Table LIII).

Here it may be pointed out that some other interesting relationships have not been considered as good although they were having high multiple correlation coefficients and low standard errors of regression coefficients. This discrimination was adopted due to non-conformance of basic considerations which are violated in these equations. Some of them bear negative effects of certain very potent resource inputs. Further more, this sort of discrimination was essential as the statistics pertaining to resource inputs were collected from secondary sources and for a single year which may have a high level of variations in certain cases.

The three equations selected as the best representative of multiple regression analysis carry different type of variable sets of packages. One of the advantages of this type of function is, that the coefficients measure also the elasticities of production/productivity in respect of each variable. Thus the sensitivity of productivity index with respect to the packaged variables lead us to some interesting results. The cause of high productivity in high productivity region is revealed by equations of combination I and II carrying significant ranks in respective order. In equation of combination I, 1 per cent increase in compost manure (variable X_8) brings a change of 0.257 per cent in productivity index, keeping other resource inputs constant, whereas 1 per cent increase in other power appliances(X_{12}) brings a change of 0.399 per ~~cent.~~ Relationship of ~~lesser significance by equati~~ of combination II indicates a relationship between productivity and variables of agricultural workers (X_9) and animal power (X_{10}). The sensitivity tested indicates that 1 per cent increase in agricultural workers leads to a negative effect on productivity in the order of 0.98 per cent, whereas 1 per cent increase in variable X_{10} (animal power) brings 3 per cent increase in the productivity index. Equation of combination IX developed from analysis identified the variables of area irrigated more than once (X_5), compost manure X_8, other power appliances (X_{12}) and agricultural credit (X_{13}) as the interacting resource inputs influencing the productivity index. Similarly, 1 per cent increase in area irrigated more than once brings a change of 0.009 in productivity, compost manure under similar conditions brings a change of 0.130 per cent in productivity. Whereas, the variables of other power appliances and agricultural credit make an increase of 0.581 and 0.16 per cent respectively in productivity index.

The concluding inferences which can be drawn from this analysis are, that variables compost manure and application of other power appliances (pumping sets and threshers in use) have most dominent influence on productivity. This calls for the application of compost manure and other power appliances in a proper manner, as they have positive influence in the high productivity region. A relationship of lesser significance exist between productivity index and variables of agricultural workers and animal power. This situation invites the attention that agricultural work force should be diverted in order to creat some other occupational opportunities to release the pressure on cultivated land. The other accompanying input of this package is animal power, which has the most dominant effect on productivity.

The conclusion of these results which identifies the causes of high productivity in high productivity region as being effective utilization of compost manure, other power appliances and animal work force. These resource inputs which can bring changes in other productivity regions provided their applications are made under similar conditions.

The results of combined analysis of the State identifies the effective variables intensity of area irrigated more than once, compost manure, other power applicances and agricultural credit in the respective order. The use of other power applicances and application of compost reappear in this relationship also indicates its relevant importance with respect to productivity. An extensive use of animal power and increased utilization of other appliances will bring considerable increase in crop productivity. The deployment of agricultural work force also needs a serious concern as it causes negative effect on productivity being under influence of the law of diminishing return.

CONCLUSION AND SUGGESTIONS

In a country where agriculture is the mainstay of the population, measurement of food crop productivity is of great importance. With the rising population at the rate of 1.82 per cent per annum, the measurement of food productivity should not only indicate imbalances in production, but also suggest the methods, how production/productivity can be increased to feed the growing population.

The writer has made an attempt to examine in the first place, the concept of agricultural productivity and then the various approaches which have been made towards ~~the measurement of~~ productivity.

After examining the problem of wastelands, ground water resources, size of land holdings, inception of Intensive Cultivation Programmes and cropping pattern, food crop productivity regions have been demarcated by four different approaches.

Food crop productivity variations computed on the basis of the selected four methods have shown significant differences in productivity indices, their changes and growth pattern in each district and in each point of time. The main reason for this is that each method has its own sensitivity and is influenced by the nature of numerator and denominator in computing productivity index. The demarcation of food crop productivity and regional differences were made on the basis of Crop Yield Index, Standard Nutrition Unit, Output per Hectare (Rs.) and Output per Agricultural Worker (Rs.).

The writer has further analysed the position of various inputs used in the agriculture of the State in detail for example, the area under high-yielding varieties, distribution of fertilizers, farm implements and machinery in use, and advancement of agricultural credit to the farmers for the adoption of modorn methods in agriculture.

In order to determine the significance of productivity index statistically among the four productivity evaluating methods e.g., Crop Yield Index, Standard Nutrition Unit, Output per Hectare (Rs.) and Output per Agricultural Worker (Rs.) for forty-eight districts of Uttar Pradesh, factor analysis was performed to decide the ranking of each productivity method. It was found through the analyses, that Standard Nutrition Unit output per hectare gave the significant value of coefficient being 0.95338 and this confirms the significance of the method (Table XLIV of Chapter X). Table LIV categorises different productivity ranks, total SNU produced for human consumption, total area covered in each productivity rank and their percentages to the total cropped area, and availability of

SNU per hectare. The two extremes of variation are evident from Table LIV, that lowest the area covered under very high productivity rank producing the highest SNU per hectare greater the area covered under very low productivity rank, and produces SNU less than 1 per hectare.

TABLE LIV

Showing total SNU produced, total area and SNU available per hectare in each productivity rank
1970-71

Productivity rank	Total SNU produced	Area under food crops (in ha.)	Percentage to the total cropped ~~area of~~ the State	SNU available per/ha.
Very High	85,95,529	13,90,514	7.09	6.18
High	61,54,579	22,21,079	11.35	2.77
Medium	56,01,907	24,60,812	12.55	2.27
Low	85,05,531	60,35,485	30.78	1.40
Very Low	50,45,880	74,95,103	38.23	0.67

An input and output analysis has also been made to establish the output (productivity) versus input (independent variables) relationship considering the productivity index (SNU) for each productivity region as demarcated in Fig.38. In the first instance significant input variables were identified by testing them through factor analysis for each productivity region as well as U.P. State considering a single unit. The values of the identified variables for each productivity region and U.P. as a whole were incorporated for multiple regression analysis taking their logarithm to incorporate in the analysis, which at last gave the equation in the form of Cobb-Douglas type of production function.

Three equations are the best expression of multiple regression analysis carrying different variable sets as packages. The cause of high productivity in high productivity region was revealed by variables of compost manure and other power appliances keeping other resource inputs constant. The second equation yielded the significance of animal power by and large the human labour force shows the negative impact on productivity. In the third equation, the variables which identify the direct bearing on productivity are intensity of area irrigated more than once, use of compost manure, application of other power appliances and advancement of agricultural credit because these variables measure the extent of enhancing the level of productivity.

Besides this analytical frame, again there are certain measures which may be regarded as the basis for increasing productivity of low and very low productivity regions of the State:

1. In areas where irrigational facilities and other water resources are available, the needed inputs like fertilizers, diesel, electricity, improved seed, weedicides and other agricultural chemicals should be given priority,
2. Area under the suitabily cultivable crops should be expanded wherever possible,
3. Plant protection chemicals, particularly the weedicides should be obtained on a priority basis and supplied in problem areas,
4. Seed is a limitation in areas particularly where ~~wheat area is to be expanded. Arrangements should~~ be made to supply the seed on a priority basis for timely sowing,
5. Credit in the form of inputs will go a long way in helping the farmers to apply them to the fields to increase the productivity. Otherwise the productivity of the fields cannot be exploited to the full measure,
6. Government should ensure supply of diesel and electricity to farmers and availability of canal water at critical stages of plant growth,
7. Government should ensure timely movement and distribution of inputs and credit to farmers.

APPENDICES

APPENDIX I

Details under administrative divisions of U.P. - 1971

Name of Commissionery	Total area Km^2	Number of Villages	Number of tehsils	Number of towns	Total population (persons)	Name of districts under the commissionery
1	2	3	4	5	6	7
Meerut	23,698 (8.04)	6,945	20	38	98,81,957 (11.18)	Dehra Dun, Saharanpur Muzaffarnagar, Meerut and Bulandshahr,
Agra	22,340 (7.58)	7,061	26	34	87,36,741 (9.88)	Aligarh, Mathura, Agra, Mainpuri and Etah,
Rohilkhand	30,538 (10.37)	16,022	32	47	1,03,01,037 (11.65)	Bareilly, Bijnor, Budauri, Moradabad, Shahjahanpur, Pilibhit and Rampur,
Allahabad	26,220 (8.90)	10,750	25	24	1,02,11,249 (11.55)	Farrukhabad, Etawah, Kanpur, Fatehpur and Allahabad,
Jhansi	29,455 (10.00)	5,200	20	26	42,91,374 (4.85)	Jhansi, Jalaun, Hamirpur and Banda,
Varanasi	26,996 (9.16)	16,978	20	28	95,11,562 (10.76)	Varanasi, Mirzapur, Jaunpur, Ghazipur and Ballia,
Gorakhpur	24,769 (8.41)	21,691	20	17	1,17,03,052 (13.24)	Gorakhpur, Deoria, Basti and Azamgarh,
Lucknow	31,158 (10.58)	10,620	22	24	98,49,864 (11.14)	Lucknow, Unnao, Rae Bareli, Sitapur, Hardoi and Kheri,
Faizabad	31,255 (10.61)	14,427	22	25	1,06,61,304 (12.06)	Faizabad, Gonda, Bahraich, Sultanpur, Pratapgarh and Bara Banki,
Garhwal	27,002 (9.16)	7,354	11	14	13,85,481 (1.56)	Chamoli, Garhwal, Tehri-Garhwal and Uttar Kashi,
Kumaon	21,032 (7.14)	5,686	12	9	18,40,161 (2.08)	Almora, Naini Tal and Pithoragarh
State Total	2,94,463	1,22,734	230	286	8,83,73,782	54 districts

Note: Figures in parenthesis refer to proportion to the State as a whole.

Source: 1. Census of India 1971, Series I, Paper 1 of 1972 Final Population.

2. Census of India 1971, Uttar Pradesh, Part II A General Population Table, Series 21.

Appendix II

Opinions of some agricultural scientists on measuring crop intensity, land, labour and capital productivity

APPENDIX II

A.N. Rakitnikov : Geographical Faculty, Moscow University, U.S.S.R.

A) Methods of measuring intensity of agriculture having necessary basic data: a/value of fixed and floating assets i.e., total of production inputs per unit area of agricultural land; b/this most general quantitative index should be supplemented by seperate calculations of value of production funds/reserves/per unit area and labour input in hours or days per unit area; c/as a supplementary index a value of gross production of agriculture per unit area should also be applied.

B) To determine land productivity either partial indices/ yields of particular crops, value of gross crop production or general quantitative expressions value of total final production could be used. The same to determine labour productivity in agriculture in relation to working hours or days. To determine economic effectiveness of capital inputs/productivity of capital inputs, a value of final production of value of fixed and floating assets should be related.

J.E. Spencer : Department of Geography, University of California, Los Angels, U.S.A.

Intensity of agriculture, I understand to be an index of how much of the year the crop surface, be it soul or water in a pond, is occupied by crops, in a ratio of how many crops are grown per year, measured normally against some kind of productivity factor. The latter could be calories or it could be dollars.

J.A. Taylor and J.W. Aitchison : Department of Geography,
University College of Wales,
Aberystwyth, U.K.

A) Intensity of production should ideally be measured by total monetary input with allowances for the work of the interpreneur and his family plus interest on his invest capital. This again would be difficult to apply and partial measures might have to suffice e.g. yields, stock densities, total grain units, or labour inputs per unit area. A slightly equivocal method would be gross output per unit area; high outputs usually intimate high inputs.

B) Land, labour and capital productivity are partial measures of agricultural productivity. They are extremely difficult to measure independently because they are complimentary rather than isolated aspects. Thus, a measure of land productivity, e.g. output per acre would not necessarily be an indicator of land potential, but rather a measure of the combined utilization of land, labour and capital. In the same way, labour productivity e.g. output per man day is as much a reflection of innate land potential and the degree of capital investment as it is of labour efficiency. In the final economic analysis land and labour reduced into the debit side of the farm account and ultimately affect capital productivity. The latter is the same, as agricultural productivity, i.e. output per unit of input in monetory terms.

B. Hofmeister : Institute of Geography, Technical University, West Berlin.

A) Intensity of agriculture refers to inputs of manpower, technical equipment and materials, such as seeds, fertilizers per unit area.

B) In order to measure land, labour and capital productivity of agriculture net yields/value/per unit area, per manpower unit, and as a percentage of total capital investment.

L. Reeds : Department of Geography, Mc Master University Hamilton, Ontario, Canada.

The best measure of the intensity of agriculture is to ascertain expenditures on capital and labour per unit area of farm land. This information is not readily available in complete form from the census. Total capitalization and number of full time farmers per unit area is available and thus the most satisfacoty index to be used in Canada. Another good indicator of intensity is the percentage of cultivated crop land per unit area.

H. Shirahama : Chiba University,
Chiba, Japan.

We do not have the overall statistics which are adequate to measure labour or capital productivity of agriculture in Japan. There is no choice then but to estimate the productivity from samples of individual farm management. Land productivity may be measured by the gross/monetary production per acreage of cultivated land per area.

APPENDIX III

Districtwise number of operational land holdings in U.P. 1971

Name of district	below 1 ha.	1-5 ha.	5-10 ha.	Above 10 ha.	Total holdings
1	2	3	4	5	6
Dehra Dun	33,813	16,181	1,293	253	51,540
Saharanpur	96,690	84,736	14,372	3,232	1,99,030
Muzaffarnagar	1,01,009	77,671	11,820	2,488	1,92,988
Meerut	1,81,757	1,22,745	13,861	2,352	3,10,025
Bulandshahr	1,18,843	1,03,050	11,409	2,109	2,35,422
Aligarh	1,05,770	97,458	14,250	2,395	2,22,873
Mathura	55,042	72,444	13,206	2,454	1,43,147
Agra	97,082	94,015	11,186	2,006	2,04,289
Mainpuri	2,14,044	46,787	5,581	835	3,07,247
Etah	1,88,641	90,159	6,955	1,143	2,86,917
Bareilly	1,80,358	99,290	6,564	1,023	2,87,235
Bijnor	85,011	77,119	11,324	2,493	1,75,947
Budaun	2,46,111	1,22,139	8,385	2,194	3,77,926
Moradabad	2,08,041	1,38,470	12,061	1,902	3,60,474
Shahjahanpur	2,20,787	99,625	6,442	1,417	3,28,231
Pilibhit	97,415	58,744	3,710	1,163	1,61,032
Rampur	91,573	54,464	3,782	948	1,50,768
Farrukhabad	2,48,470	1,37,637	5,669	950	3,40,221
Etawah	1,72,922	90,663	6,352	980	2,70,917
Kanpur	2,50,014	1,26,662	9,092	1,420	3,87,233
Fatehpur	1,33,663	79,689	8,931	4,020	2,24,415
Allahabad	5,76,095	1,24,609	12,119	4,856	4,77,263
Jhansi	86,041	1,14,730	23,552	8,413	2,32,736
Jalaun	50,248	64,732	15,247	5,462	1,35,689
Hamirpur	67,285	90,087	22,027	10,093	1,89,492
Banda	1,04,275	97,132	1,97304	9,182	2,30,323
Varanasi	3,50,385	78,814	5,756	1,341	4,36,698
Mirzapur	1,49,492	83,332	13,317	6,732	2,52,873

(contd....)

APPENDIX III (Contd...)

1	2	3	4	5	6
Jaunpur	4,43,827	79,788	4,137	601	5,28,427
Ghazipur	1,90,372	65,656	6,159	1,435	2,63,622
Ballia	1,92,367	58,843	5,645	1,547	2,58,402
Gorakhpur	4,19,294	1,22,694	7,558	2,330	5,51,876
Deoria	3,84,840	1,15,116	6,988	1,968	5,08,912
Basti	4,93,063	1,53,283	10,198	23,734	6,59,257
Azamgarh	5,51,630	1,14,775	7,270	1,442	6,75,073
Naini Tal	23,662	32,104	7,228	2,111	65,105
Lucknow	1,10,138	50,765	2,294	496	1,63,690
Unnao	2,12,899	95,578	4,924	978	3,14,379
Rae Bareli	2,42,460	87,749	4,215	738	3,35,162
Sitapur	2,52,037	1,36,183	8,204	1,741	3,98,165
Hardoi	2,72,310	1,32,070	8,055	1,623	4,14,058
Kheri	2,11,312	1,25,816	9,375	2,999	3,49,500
Faizabad	3,33,483	88,332	4,229	773	4,22,817
Gonda	3,68,185	1,45,694	11,402	2,571	5,27,848
Bahraich	2,97,962	1,30,149	8,996	2,159	4,39,266
Sultanpur	3,21,053	84,085	5,399	1,098	4,11,635
Pratapgarh	2,49,443	74,541	3,963	820	3,28,767
Bara Banki	2,62,435	91,678	4,354	863	3,59,330
Uttar Pradesh	1,01,03,229	45,17,568	4,28,585	1,12,111	1,51,58,932

APPENDIX IV

Districtwise details of area under food crops in U.P. - 1950-51

(Area in hectares)

Name of district	Rice	Jowar	Bajra	Maize	Wheat	Barley	Gram	Sugarcane	Potato	Arhar	Pulses	Oilseeds
1	2	3	4	5	6	7	8	9	10	11	12	13
Dehra Dun	11,758	-	49	5,148	17,642	3,942	2,214	1,316	187	1,478	5,265	1,104
Saharanpur	65,723	610	23,113	27,498	1,14,774	6,835	70,465	45,963	451	98	12,116	1,009
Muzaffarnagar	26,544	4,145	15,192	15,430	1,02,140	5,542	53,990	68,880	442	182	19,972	1,411
Meerut	16,729	31,336	31,667	38,812	1,42,337	19,981	60,062	1,07,697	1,930	5,024	46,824	1,400
Bulandshahr	6,651	32,185	46,236	54,746	85,440	66,114	39,024	46,028	1,614	10,288	55,254	1,868
Aligarh	5,766	15,272	99,210	39,427	86,846	67,498	50,689	16,052	2,309	20,953	43,954	5,820
Mathura	449	39,620	50,314	3,640	54,332	40,364	65,472	14,442	546	12,844	14,511	17,737
Agra	217	23,766	1,00,330	1,027	53,836	36,487	80,359	6,252	1,066	31,436	8,065	6,818
Mainpuri	29,927	27,230	41,530	23,809	61,479	29,352	39,579	7,825	2,407	16,877	15,390	5,938
Etah	13,843	16,414	76,472	30,772	86,847	38,842	28,148	13,343	2,615	18,020	25,871	517
Bareilly	86,990	20,469	23,498	8,330	77,234	6,134	48,761	33,703	1,343	10,758	14,314	4,630
Bijnor	79,486	118	17,676	657	70,985	19,702	40,679	43,490	323	538	15,622	1,981
Budaun	28,341	21,542	91,632	19,083	1,25,234	31,021	45,791	24,100	1,526	27,232	18,526	7,239
Moradabad	73,443	15,039	52,020	6,577	1,45,499	33,508	49,900	49,073	1,476	12,742	26,121	7,271
Shahjahanpur	66,844	20,006	26,852	1,424	86,472	13,381	47,304	26,228	2,014	13,054	20,298	428
Pilibhit	64,016	2,766	4,261	170	39,652	3,397	27,826	20,319	726	2,331	13,107	794
Rampur	38,039	12,280	4,935	12,915	37,350	3,124	22,677	16,595	350	3,790	4,842	1,871
Farrukhabad	24,454	37,592	23,760	28,028	64,630	28,387	42,342	14,773	8,973	14,607	11,907	9,701
Etawah	31,547	21,151	51,000	14,179	38,760	26,167	44,361	9,326	1,760	21,996	18,303	9,164
Kanpur	66,734	67,705	24,718	15,233	61,785	59,901	87,388	6,388	2,444	29,839	17,071	13,577
Fatehpur	56,138	43,565	9,088	117	26,259	47,608	63,352	6,684	1,297	16,963	12,252	1,024
Allahabad	1,27,266	38,566	40,434	218	35,553	74,771	86,084	7,074	3,349	25,008	35,832	4,061
Jhansi	13,434	91,704	537	10,052	75,328	13,812	93,057	611	290	9,501	11,459	3,290
Jalaun	1,535	35,338	22,209	6	76,820	13,935	1,20,570	1,489	304	18,498	6,908	7,911
Hamirpur	7,798	[illegible],170	4,787	4	92,065	7,169	1,46,927	1,524	24	24,357	2,306	9,300
Banda	59,455	[illegible],388	11,390	23	69,359	13,144	1,53,585	824	125	24,234	5,258	5,264

(contd.....)

APPENDIX IV (Contd....)

1	2	3	4	5	6	7	8	9	10	11	12	13
Varanasi	1,32,547	7,520	10,348	6,716	24,646	56,294	43,042	21,852	2,682	17,340	33,661	1,032
Mirzapur	1,22,801	6,619	8,856	10,347	26,262	39,092	43,702	5,666	668	15,901	11,772	5,814
Jaunpur	90,643	10,729	6,551	47,239	22,177	80,745	14,086	23,032	4,198	14,100	30,813	106
Ghazipur	94,160	5,220	10,342	3,259	12,138	51,002	33,902	13,695	1,204	14,179	27,675	242
Ballia	76,227	2,589	2,894	12,097	16,428	45,020	46,593	16,052	1,364	10,310	25,037	432
Gorakhpur	2,23,577	65	167	7,817	66,631	91,364	21,189	15,633	2,685	3,358	59,892	6,143
Deoria	1,77,361	189	1,088	19,007	61,968	72,191	16,230	53,927	1,762	9,606	61,270	2,144
Basti	2,99,268	17	52	19,002	1,20,623	80,862	24,459	22,382	3,342	1,829	85,269	5,923
Azamgarh	1,78,688	669	603	13,993	22,479	1,07,030	24,596	30,638	2,384	18,769	53,730	650
Naini Tal	42,407	350	102	2,572	20,211	2,180	9,868	5,348	170	68	4,657	7,997
Lucknow	34,458	9,912	10,512	5,732	34,476	14,442	20,280	3,179	1,696	11,580	14,515	3,105
Unnao	44,911	24,227	10,940	19,877	50,957	56,713	29,037	11,199	1,506	25,882	12,577	9,856
Rae Bareli	88,164	25,198	7,722	88	43,802	43,429	27,744	2,996	908	21,247	32,640	724
Sitapur	1,15,327	4,811	14,338	9,571	88,110	5,903	64,354	33,798	1,300	5,697	40,924	12,802
Hardoi	41,580	30,213	24,908	17,379	87,588	52,656	55,220	27,205	3,298	33,007	33,704	19,213
Kheri	1,08,415	5,426	9,090	31,108	77,530	38,583	53,260	42,338	1,150	8,342	23,290	7,106
Faizabad	1,22,274	5,208	50	9,173	54,172	28,378	51,634	22,279	2,572	5,896	41,440	450
Gonda	2,19,951	1,004	726	93,607	1,10,750	39,981	45,526	18,041	2,354	4,013	46,383	9,830
Bahraich	1,60,097	1,194	747	1,12,188	98,754	57,282	35,536	5,020	1,204	1,914	28,478	12,012
Sultanpur	1,15,423	15,739	1,410	3,658	37,558	39,198	42,726	9,770	1,830	14,612	34,786	156
Pratapgarh	71,269	12,184	17,679	2,018	24,483	52,192	19,739	5,076	1,201	24,824	25,180	207
Bara Banki	1,07,432	59,252	3,716	10,154	60,429	18,703	74,072	22,631	1,317	4,677	32,656	1,796
Uttar Pradesh	38,52,213	9,41,129	10,44,747	8,33,948	33,15,665	19,47,417	24,39,316	10,13,552	82,035	6,47,616	12,58,236	2,58,387

Source: Crop Statistics of U.P., 1950-51 to 1960-61, Vol.II, Allahabad, 1967.

APPENDIX V

Districtwise details of area under food crops in U.P. - 1960-61

(Area in hectares)

Name of district	Rice	Jowar	Bajra	Maize	Wheat	Barley	Gram	Sugarcane	Potato	Arhar	Pulses	Oilseeds
1	2	3	4	5	6	7	8	9	10	11	12	13
Dehra Dun	13,523	-	59	9,453	16,165	960	1,885	734	131	16	3,291	1,118
Saharanpur	89,048	561	17,891	31,234	1,14,104	4,030	50,691	77,671	8,322	472	12,917	5,924
Muzaffarnagar	32,232	3,106	11,314	21,582	1,06,072	1,625	32,506	1,01,479	721	520	17,828	497
Meerut	16,314	15,663	28,468	47,993	1,58,156	12,431	37,075	1,39,904	3,069	4,011	47,692	698
Bulandshahr	5,038	24,464	47,486	58,602	1,02,580	58,048	25,923	67,071	1,890	8,059	56,925	1,082
Aligarh	7,632	6,530	1,01,615	42,397	99,780	55,838	40,716	34,316	2,311	15,559	68,315	2,191
Mathura	229	29,525	54,270	7,161	78,416	35,759	62,527	22,620	509	14,584	19,454	10,676
Agra	721	14,014	1,03,386	1,257	71,565	37,625	89,407	9,097	1,550	31,392	12,584	8,828
Mainpuri	47,680	12,770	51,096	26,422	68,264	27,824	39,056	7,187	3,636	11,883	32,028	8,780
Etah	17,144	6,926	80,531	37,625	86,797	27,763	36,647	17,375	3,156	14,941	36,341	17,332
Bareilly	95,402	16,644	20,254	11,409	84,753	4,349	52,355	38,480	1,642	8,662	22,256	12,681
Bijnor	80,340	504	16,938	3,498	83,040	14,086	36,328	63,996	522	1,293	11,801	4,644
Budaun	24,852	14,506	84,387	23,068	1,35,820	19,781	43,054	24,278	2,482	23,748	28,604	30,394
Moradabad	66,206	15,593	52,302	14,554	1,62,066	20,513	39,635	63,019	2,477	13,942	24,785	21,895
Shahjahanpur	76,927	17,989	27,381	4,726	89,490	17,434	53,146	29,880	2,385	12,170	16,296	3,572
Pilibhit	80,515	3,141	4,965	5,098	52,643	4,125	29,826	32,033	875	2,970	17,756	1,539
Rampur	45,453	14,056	5,028	29,222	49,744	2,174	36,986	28,998	981	4,613	6,910	3,638
Farrukhabad	22,538	31,763	23,680	38,128	77,106	24,537	41,386	12,556	13,093	12,642	15,157	16,801
Etawah	46,973	12,792	59,012	21,337	53,450	24,418	45,147	7,178	2,657	19,305	33,866	9,837
Kanpur	59,533	64,294	30,348	22,758	98,745	56,225	79,416	5,394	4,258	30,411	23,227	15,818
Fatehpur	68,777	45,525	11,650	212	31,300	48,526	77,407	5,726	1,694	18,334	8,448	1,525
Allahabad	1,43,433	32,466	50,226	488	54,220	87,379	96,712	6,186	4,221	25,960	37,644	1,918
Jhansi	16,772	1,18,764	232	11,060	12,540	11,104	1,06,347	1,111	430	17,919	15,356	2,772
Jalaun	3,489	41,602	19,926	17	95,444	18,187	1,32,399	2,867	384	20,422	6,877	9,537
Hamirpur	5,874	97,864	2,942	9	1,26,162	7,520	1,73,248	1,794	83	32,772	445	9,424
Banda	87,237	74,690	13,162	17	1,11,756	16,922	1,81,666	188	158	29,218	7,391	5,210
Varanasi	1,39,436	4,188	17,443	8,654	34,254	56,472	36,758	19,092	3,284	19,542	27,885	1,821
Mirzapur	1,28,325	8,247	13,002	11,558	43,022	49,659	49,181	5,524	871	20,737	13,062	17,275

(contd.....)

APPh (Contd.....)

1	2	3	4	5	6	7	8	9	10	11	12	13
Jaunpur	95,097	6,844	8,330	39,781	26,732	86,592	15,168	17,904	4,571	11,423	26,530	61
Ghazipur	90,983	4,995	13,616	4,030	15,277	53,280	33,311	13,885	1,754	17,214	26,592	504
Ballia	68,991	2,908	5,875	19,694	19,598	48,646	37,199	15,538	2,217	19,049	20,302	606
Gorakhpur	2,32,617	194	397	9,482	82,333	90,653	24,630	25,176	3,236	3,247	52,349	7,101
Deoria	1,65,257	1,033	1,576	22,052	70,356	59,324	10,863	81,704	2,098	7,451	45,385	1,592
Basti	2,90,584	40	129	22,265	1,10,284	80,835	28,156	33,476	3,926	747	69,084	5,095
Azamgarh	1,91,958	806	721	16,900	21,591	1,06,213	22,441	38,760	3,043	22,546	54,222	405
Naini Tal	63,619	694	79	23,987	45,329	2,738	21,582	23,771	210	379	12,766	13,335
Lucknow	37,734	9,459	8,609	5,504	40,176	14,584	25,535	2,225	2,186	9,832	15,636	5,651
Unnao	67,745	24,573	11,332	25,464	62,829	57,776	34,611	1,775	1,926	24,464	15,109	12,853
Rae Bareli	1,05,578	26,964	10,386	264	51,598	48,316	31,586	2,910	1,387	22,997	31,628	4,014
Sitapur	1,01,705	6,796	10,943	31,198	1,05,642	46,078	72,160	39,857	1,240	4,878	32,469	23,439
Hardoi	57,390	26,948	18,158	21,358	96,699	51,575	68,830	20,528	3,538	24,348	37,233	33,518
Kheri	1,19,550	6,520	6,515	47,357	97,547	25,929	54,764	73,944	1,395	7,444	20,792	12,862
Faizabad	1,30,290	4,874	134	8,652	69,614	32,199	58,703	21,904	3,150	5,315	45,550	432
Gonda	2,38,124	1,014	1,734	99,868	1,30,945	37,756	51,306	25,126	2,794	2,984	48,498	13,544
Bahraich	1,74,708	1,366	1,347	1,27,734	1,11,366	39,959	48,743	4,575	1,297	1,873	32,431	16,441
Sultanpur	1,24,143	13,849	4,365	4,538	42,590	37,426	49,414	9,939	2,329	13,927	35,859	209
Pratapgarh	78,279	9,168	19,128	2,341	27,257	52,566	23,221	4,065	1,654	22,994	23,166	314
Bara Banki	1,18,124	6,736	4,380	9,604	68,753	18,686	84,813	19,867	2,137	5,392	26,323	2,650
Uttar Pradesh	40,20,000	8,94,000	10,89,000	10,43,000	37,50,000	17,56,000	25,52,000	13,28,000	1,07,000	6,52,000	13,32,000	3,99,000

Source: Crop Statistics of U.P., 1950-51 to 1960-61, Vol.II, Allahabad, 1967.

APPENDIX VI

Districtwise details of area under food crops in U.P. - 1970-71

(Area in hectares)

Name of district	Rice	Jowar	Bajra	Maize	Wheat	Barley	Gram	Sugarcane	Potato	Arhar	Pulses	Oilseeds
1	2	3	4	5	6	7	8	9	10	11	12	13
Dehra Dun	13,247	-	12	12,142	23,326	2,837	938	5,738	454	88	2,772	1,099
Saharanpur	87,814	194	13,472	40,100	1,70,301	2,170	24,926	89,665	760	132	9,381	11,945
Muzaffarnagar	39,814	503	4,253	27,765	1,54,401	475	13,589	1,24,328	1,106	51	9,700	445
Meerut	27,258	2,553	19,480	78,409	2,27,616	4,814	23,712	1,43,698	5,892	1,001	28,519	371
Bulandshahr	9,721	12,021	37,932	1,12,716	1,99,027	27,023	23,284	48,473	4,063	2,941	30,709	1,803
Aligarh	15,550	4,088	1,06,318	75,870	2,05,029	40,813	26,137	18,919	2,671	5,142	37,871	2,607
Mathura	5,585	17,272	65,737	10,516	1,50,270	34,337	31,179	18,084	823	7,134	18,688	5,686
Agra	2,823	7,213	1,16,885	3,996	1,28,989	18,003	58,741	4,548	1,545	22,001	15,291	27,329
Mainpuri	45,740	10,034	52,824	51,727	1,27,484	12,972	24,252	3,643	6,946	7,896	17,839	15,092
Etah	24,641	6,449	85,410	58,347	1,37,527	13,592	22,057	10,810	3,842	9,941	29,362	8,742
Bareilly	97,287	17,806	15,738	18,124	1,22,144	2,218	32,641	39,169	1,964	7,957	15,918	26,388
Bijnor	95,022	498	7,623	8,076	1,17,894	4,459	25,373	81,232	971	1,150	11,375	15,256
Budaun	32,257	11,032	85,245	43,598	1,66,465	7,909	28,578	23,803	3,770	17,423	24,158	50,731
Moradabad	86,835	14,239	57,887	46,209	2,23,484	7,048	21,865	64,711	3,486	9,493	17,481	23,715
Shahjahanpur	82,659	14,781	26,787	10,081	1,24,020	8,805	34,874	32,326	3,008	9,754	24,198	16,732
Pilibhit	92,401	2,740	4,516	4,562	83,485	2,415	17,580	34,827	788	2,756	11,067	5,319
Rampur	54,138	14,697	5,571	30,553	83,103	1,859	21,122	22,092	1,312	4,364	5,255	5,511
Farrukhabad	22,858	19,185	19,828	77,694	1,15,723	12,745	26,570	8,416	22,457	7,839	9,942	25,434
Etawah	54,723	8,221	64,002	33,555	99,955	14,780	30,968	5,939	4,402	17,430	21,456	17,793
Kanpur	63,935	48,295	3,458	33,467	1,17,702	42,998	77,052	5,759	5,381	26,635	20,100	29,385
Fatehpur	67,924	36,158	20,852	745	53,285	47,497	74,222	7,901	1,924	18,312	8,944	3,534
Allahabad	1,39,225	35,913	65,644	2,130	94,619	77,031	83,184	5,176	7,651	30,391	27,248	12,157
Jhansi	17,737	1,09,002	875	16,641	1,58,607	7,970	1,22,770	993	729	18,299	19,466	3,650
Jalaun	11,378	25,006	23,744	34	1,19,415	9,164	1,33,373	1,872	441	15,949	22,491	11,563
Hamirpur	8,653	80,086	4,185	6	1,40,321	4,517	1,95,065	2,219	102	27,955	8,946	10,531
Banda	82,394	69,802	24,454	30	1,22,730	14,130	2,05,299	933	258	31,409	13,032	4,465

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APPENDIX VI (Contd....)

1	2	3	4	5	6	7	8	9	10	11	12	13
Varanasi	1,43,615	5,660	16,878	15,266	59,984	51,173	30,314	19,206	4,666	20,210	24,936	3,310
Mirzapur	1,29,691	6,805	14,466	19,143	63,883	41,924	37,395	4,649	1,865	21,753	13,691	19,168
Jaunpur	87,540	6,392	9,318	62,279	50,970	80,015	9,551	18,129	6,616	11,964	21,033	94
Ghazipur	95,580	6,253	23,159	7,438	35,412	52,538	27,994	15,600	2,421	26,737	23,779	522
Ballia	76,857	2,085	5,413	24,733	40,216	40,886	33,044	17,193	2,617	14,752	18,919	371
Gorakhpur	2,55,492	64	196	10,613	1,85,015	44,446	15,375	25,196	4,153	2,641	32,941	9,629
Deoria	1,90,268	543	1,467	26,447	1,46,150	40,961	10,607	74,005	2,543	7,625	33,323	2,997
Basti	3,21,402	2	19	21,491	1,91,484	44,319	19,371	31,723	4,704	1,219	65,645	5,632
Azamgarh	2,06,174	269	831	22,701	52,333	1,01,160	19,283	39,496	4,340	25,240	49,146	344
Naini Tal	72,853	189	180	26,982	74,055	1,575	15,119	39,110	298	211	10,204	18,053
Lucknow	39,276	9,607	9,653	8,928	53,675	9,294	18,524	2,666	3,447	9,492	8,103	7,154
Unnao	68,658	23,178	8,241	36,417	97,627	53,462	32,776	6,958	2,298	21,180	13,277	18,153
Rae Bareli	1,07,534	28,320	11,797	1,104	71,270	48,369	23,643	2,842	1,988	24,362	27,486	6,595
Sitapur	90,983	6,422	8,243	35,695	1,47,658	24,959	61,922	42,806	1,706	6,276	22,508	32,417
Hardoi	56,152	25,703	12,557	47,215	1,37,809	38,211	58,701	22,045	4,141	20,702	22,599	62,643
Kheri	1,20,561	5,248	4,187	51,952	1,37,064	12,166	42,825	88,326	1,241	5,835	21,329	32,751
Faizabad	1,42,780	6,237	218	11,757	93,403	20,623	35,358	25,819	5,165	6,906	39,401	503
Gonda	2,42,149	1,048	1,302	1,01,505	1,51,572	27,206	45,354	23,795	3,001	3,965	44,948	15,201
Bahraich	1,62,555	581	799	1,46,637	1,46,774	26,851	37,851	6,011	110	1,505	23,082	22,348
Sultanpur	1,36,829	14,713	2,775	6,450	57,009	37,089	39,392	9,405	3,841	14,856	30,522	340
Pratapgarh	83,402	9,575	20,569	2,742	30,290	51,033	18,966	4,270	3,192	24,562	25,602	561
Bara Banki	1,26,622	7,562	4,796	13,087	97,041	14,211	65,619	20,678	4,397	6,940	20,038	4,410
Uttar Pradesh	44,17,696	7,34,243	11,20,916	14,97,675	55,87,554	13,23,052	20,77,917	13,45,212	1,55,525	5,82,376	10,53,704	6,12,293

Source: Bulletin of Agricultural Statistics for U.P. 1970-71, Directorate of Agriculture, U.P., Lucknow.

APPENDIX VII

Districtwise details of food crops production in U.P. - 1950-51

(Production in metric tonnes)

Name of district	Rice	Jowar	Bajra	Maize	Wheat	Barley	Gram	Sugarcane	Potato	Arhar	Pulses	Oilseeds
1	2	3	4	5	6	7	8	9	10	11	12	13
Dehra Dun	13,691	-	27	3,009	16,973	4,060	447	54,318	1,560	3,202	-	427
Saharanpur	41,768	473	11,733	18,600	1,03,578	9,103	40,142	16,58,971	3,629	213	-	5,111
Muzaffarnagar	18,890	1,401	5,509	7,284	1,17,400	6,968	36,192	24,85,132	3,304	394	-	589
Meerut	7,087	15,134	13,778	16,954	1,49,093	23,876	37,644	38,87,133	14,416	10,880	-	528
Bulandshahr	2,601	18,371	19,788	32,823	84,672	56,321	14,477	14,82,976	12,059	22,279	-	720
Aligarh	5,463	4,636	75,375	27,583	73,887	61,408	25,602	2,75,301	18,571	25,875	-	2,177
Mathura	394	17,347	23,148	2,370	45,542	39,753	34,593	3,46,982	4,398	15,861	-	6,669
Agra	160	9,157	62,682	369	48,438	40,928	51,283	1,50,140	8,576	38,819	-	2,283
Mainpuri	14,155	11,365	33,941	22,441	61,633	46,788	23,172	1,61,358	19,359	20,841	-	4,095
Etah	14,599	7,474	52,762	29,014	62,697	37,884	19,264	3,30,130	22,535	22,253	-	4,182
Bareilly	33,413	10,251	9,695	4,949	50,912	3,432	24,577	9,64,715	10,034	11,325	-	4,120
Bijnor	46,992	64	7,610	462	59,137	11,699	18,856	15,57,808	12,731	882	-	1,463
Budaun	15,107	10,742	57,166	18,551	92,845	16,647	22,321	7,51,999	12,273	28,668	-	7,737
Moradabad	37,063	8,787	19,841	3,908	1,11,371	21,571	23,375	16,84,362	11,453	13,414	-	7,638
Shahjahanpur	35,601	10,375	15,724	1,384	66,720	8,946	32,052	7,82,277	17,358	13,742	-	213
Pilibhit	42,878	1,426	2,804	194	27,769	1,769	11,678	5,83,383	5,424	2,454	-	364
Rampur	25,245	7,175	2,001	7,673	27,278	2,024	10,575	5,71,757	2,720	3,990	-	743
Farrukhabad	15,640	27,090	16,075	26,520	40,495	32,405	20,837	2,95,609	72,168	23,186	-	8,099
Etawah	17,755	19,052	50,678	15,856	35,072	34,417	26,358	2,41,998	13,146	34,912	-	4,072
Kanpur	38,167	58,704	20,292	9,281	50,080	76,745	55,318	1,65,892	19,662	47,362	-	5,418
Fatehpur	25,414	32,595	4,496	88	21,103	39,411	46,966	1,54,011	10,435	26,924	-	392
Allahabad	60,305	27,791	31,562	165	23,035	60,149	46,470	1,24,866	26,935	39,694	-	1,390
Jhansi	3,850	50,925	428	7,885	56,360	18,501	58,979	12,636	2,502	7,343	-	1,267
Jalaun	532	17,652	16,803	5	60,903	12,240	67,534	35,235	2,626	14,298	-	3,226
Hamirpur	3,027	51,812	2,898	4	82,977	5,020	1,00,275	26,737	166	18,826	-	4,534

(Contd.....)

APPENDIX VIII

Districtwise details of food crops production in U.P. - 1960-61

(Production in metric tonnes)

Name of district	Rice	Jowar	Bajra	Maize	Wheat	Barley	Gram	Sugarcane	Potato	Arhar	Pulses	Oilseeds
1	2	3	4	5	6	7	8	9	10	11	12	13
Dehra Dun	13,583	-	17	10,038	17,527	840	1,501	1,88,068	2,719	2,066	1,670	396
Saharanpur	83,530	176	5,716	19,651	98,190	3,522	32,292	33,01,707	6,686	942	10,055	3,996
Muzaffarnagar	31,379	972	2,767	17,172	1,29,362	1,420	26,570	49,54,899	5,795	1,038	13,410	196
Meerut	16,448	3,637	7,224	31,675	2,09,710	10,500	40,466	63,47,267	24,668	8,007	52,983	299
Bulandshahr	4,949	3,301	14,644	27,291	1,46,054	66,070	14,601	30,08,523	10,851	16,088	67,230	479
Aligarh	6,197	384	27,765	10,217	1,07,727	49,385	26,028	9,72,964	17,249	42,067	65,688	1,419
Mathura	185	3,884	13,855	1,038	94,442	43,728	66,911	9,40,170	4,388	17,645	15,993	4,633
Agra	591	2,080	30,903	182	97,636	44,661	1,06,416	3,49,858	11,566	70,254	14,937	4,884
Mainpuri	40,677	1,119	12,688	8,972	76,552	23,423	34,589	2,76,391	27,138	34,064	28,246	6,263
Etah	13,898	407	26,993	25,857	1,12,796	28,133	26,963	3,26,431	21,742	23,153	41,744	12,804
Bareilly	83,298	5,257	5,332	6,510	72,447	2,723	33,121	15,57,808	12,731	9,187	13,376	10,865
Bijnor	62,646	177	4,269	1,996	89,417	8,447	22,952	27,93,821	4,197	1,371	4,746	3,865
Budaun	19,447	4,657	39,647	14,558	1,20,697	13,768	26,498	4,72,484	21,374	21,563	20,425	16,219
Moradabad	42,771	5,213	19,114	8,305	1,41,402	11,938	20,500	30,31,020	15,644	16,625	16,863	15,726
Shahjahanpur	84,490	2,897	5,398	2,696	86,317	13,800	29,299	11,84,120	19,171	13,724	14,847	2,482
Pilibhit	64,552	1,101	1,454	2,909	36,079	2,583	10,280	11,37,348	6,782	3,150	7,321	622
Rampur	44,064	9,583	1,473	17,458	53,756	1,362	15,425	9,95,960	7,888	4,893	3,268	1,581
Farrukhabad	23,469	13,592	9,497	27,876	97,389	28,522	16,032	3,28,905	97,706	19,907	20,480	18,798
Etawah	52,503	3,640	26,157	9,239	62,058	33,061	27,526	3,49,838	19,832	33,522	48,054	5,984
Kanpur	57,306	35,058	12,745	13,651	1,17,142	67,965	68,775	2,62,900	26,888	76,070	33,450	14,228
Fatehpur	61,614	39,527	6,179	133	29,915	34,697	63,131	2,79,079	13,616	34,254	8,128	1,006
Allahabad	97,875	28,042	29,860	519	47,096	91,507	66,540	3,01,477	21,809	51,425	39,450	3,774
Jhansi	9,259	63,295	101	5,995	1,50,377	10,190	82,084	39,697	3,702	16,921	6,542	1,014
Jalaun	1,823	19,649	5,016	10	1,10,058	18,929	1,03,437	1,02,408	2,751	21,577	4,769	3,325
Hamirpur	3,011	58,113	1,269	5	1,41,937	6,901	1,09,972	64,081	672	38,881	2,025	3,102
Banda	91,865	48,939	5,678	9	1,14,993	15,529	1,22,945	6,714	1,360	39,045	1,839	1,760

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APPENDIX VIII (Contd....)

1	2	3	4	5	6	7	8	9	10	11	12	13
Varanasi	1,15,061	2,893	20,476	4,494	27,564	59,503	22,624	5,90,656	24,506	25,006	25,629	191
Mirzapur	1,22,921	8,493	16,208	8,795	28,698	45,423	27,781	2,00,734	6,240	9,491	7,604	4,215
Jaunpur	72,900	2,442	4,298	17,964	24,663	90,877	8,080	8,46,573	39,362	16,538	26,199	11
Ghazipur	56,102	5,484	21,486	3,251	12,563	60,458	20,066	5,04,566	16,117	10,434	25,349	113
Ballia	32,399	3,385	1,181	21,087	21,530	52,380	35,643	7,08,061	16,545	12,216	16,809	226
Gorakhpur	1,58,926	162	434	5,000	64,047	58,573	13,265	12,50,042	18,575	1,292	33,797	3,020
Deoria	99,604	863	1,722	18,396	60,050	45,694	5,010	34,39,974	15,059	5,419	31,550	497
Basti	1,89,390	34	142	8,624	85,163	32,772	19,847	15,25,086	28,175	310	51,823	1,673
Azamgarh	1,17,145	674	788	13,921	21,401	1,27,315	9,977	16,71,453	13,977	8,223	56,910	130
Naini Tal	63,380	243	29	23,817	43,680	2,127	12,153	12,06,582	1,449	397	5,825	7,077
Lucknow	23,791	5,505	3,027	2,334	46,876	13,722	29,377	78,995	6,904	12,018	10,794	5,979
Unnao	51,921	22,019	3,984	10,044	55,064	55,870	30,297	2,66,922	15,484	34,469	11,002	13,659
Rae Bareli	79,875	33,204	3,652	112	50,532	43,811	35,728	1,01,135	11,944	33,292	24,527	4,158
Sitapur	56,968	3,955	2,274	14,861	88,636	30,784	65,269	13,21,257	8,888	5,963	15,764	18,938
Hardoi	39,816	10,592	3,023	7,975	95,281	48,263	40,401	7,30,096	32,497	16,187	30,118	29,837
Kheri	74,289	3,794	2,291	28,129	74,840	14,735	29,788	23,02,337	9,096	9,099	8,942	10,091
Faizabad	92,691	2,751	72	4,969	78,397	36,560	42,214	10,07,624	19,892	3,565	47,093	127
Gonda	1,35,328	881	930	63,790	84,238	18,463	18,881	8,38,327	20,012	1,568	29,879	3,236
Bahraich	83,783	1,187	722	80,857	59,945	20,145	16,443	1,48,114	5,957	812	12,229	6,683
Sultanpur	80,434	11,018	2,340	1,406	42,100	46,041	42,968	4,22,988	17,381	17,136	34,730	55
Pratapgarh	46,434	6,731	15,084	685	22,446	41,726	12,285	1,73,015	11,396	23,368	16,897	81
Bara Banki	93,732	5,851	2,349	6,308	74,935	17,270	69,385	7,36,909	14,721	9,504	19,405	1,597
Uttar Pradesh	31,50,000	4,94,000	4,29,000	6,25,000	39,44,000	16,87,000	18,31,000	5,45,15,000	7,99,000	8,85,000	11,06,000	2,52,000

Source: Crop Statistics of U.P., 1950-51 to 1960-61, Vol.II, Allahabad, 1967.

APPENDIX IX

Districtwise details of food crops production in U.P. - 1970-71

(Production in metric tonnes)

Name of district	Rice	Jowar	Bajra	Maize	Wheat	Barley	Gram	Sugarcane	Potato	Arhar	Pulses	Oilseeds
1	2	3	4	5	6	7	8	9	10	11	12	13
Dehra Dun	14,299	-	5	14,999	26,342	1,738	693	2,23,979	4,264	222	1,217	492
Saharanpur	1,00,528	30	5,645	43,024	2,13,234	1,329	12,333	37,09,630	7,137	334	4,314	6,988
Muzaffarnagar	42,649	78	1,130	29,645	2,51,180	291	10,554	58,76,848	10,386	129	5,620	210
Meerut	29,899	395	8,445	1,15,473	3,72,503	3,945	20,135	65,47,501	55,333	2,531	25,241	165
Bulandshahr	8,736	2,193	21,025	1,92,073	4,39,685	29,500	23,087	15,28,376	38,157	7,435	34,661	804
Aligarh	11,377	1,223	1,07,806	1,07,887	4,22,155	69,505	23,314	4,49,429	25,084	7,367	49,827	1,780
Mathura	4,360	2,448	48,745	9,952	2,64,267	53,911	43,095	6,02,056	7,729	11,481	20,416	4,154
Agra	2,081	2,158	76,461	3,782	1,67,277	15,872	35,310	1,77,857	14,509	29,937	10,226	20,977
Mainpuri	30,216	3,604	40,232	75,285	1,78,208	21,904	20,681	1,42,465	55,840	15,397	13,601	10,495
Etah	17,258	1,929	77,080	94,062	1,98,144	20,742	29,575	3,70,492	36,081	13,956	36,375	11,564
Bareilly	80,077	9,998	12,275	19,150	1,43,309	1,470	19,341	15,44,281	18,632	8,388	8,056	14,809
Bijnor	78,104	189	2,228	8,533	1,41,860	2,661	13,554	37,00,367	9,148	1,212	6,250	8,167
Budaun	30,201	6,925	74,170	59,834	2,33,328	4,971	18,897	8,33,689	35,489	18,367	24,096	25,079
Moradabad	69,206	5,030	40,328	48,824	3,30,176	5,869	10,580	28,30,196	32,738	12,798	12,483	13,510
Shahjahanpur	85,563	5,733	20,048	10,652	1,39,432	8,729	25,528	13,62,976	28,249	10,283	16,812	9,020
Pilibhit	79,660	1,039	1,320	4,820	92,733	1,601	11,934	14,52,756	7,400	2,905	5,187	1,511
Rampur	55,547	16,488	1,629	35,436	1,37,878	1,232	14,702	9,05,110	12,321	4,601	2,877	2,686
Farrukhabad	18,865	12,615	16,964	1,40,708	1,55,189	14,699	17,722	2,95,248	2,10,900	11,272	8,033	20,393
Etawah	17,283	4,746	66,767	40,134	1,76,551	17,432	32,565	2,08,350	41,340	21,337	29,640	20,273
Kanpur	54,853	42,794	25,184	50,771	1,85,561	68,032	80,507	2,02,035	50,534	48,291	20,653	15,740
Fatehpur	46,039	24,914	10,153	1,193	74,070	43,616	78,680	2,77,181	18,069	40,645	4,809	2,556
Allahabad	95,591	21,144	45,995	3,409	1,02,495	86,968	70,029	1,81,583	71,852	43,842	21,030	4,755
Jhansi	10,137	65,403	316	25,459	1,86,055	7,112	66,755	30,755	6,847	9,175	11,793	983
Jalaun	6,324	11,550	6,392	52	1,19,216	8,044	73,108	57,979	4,141	15,945	23,496	3,451
Hamirpur	4,770	59,619	1,512	9	1,49,969	4,030	1,21,977	68,726	958	24,333	7,274	3,270
Banda	67,689	42,796	11,020	46	1,39,483	9,761	1,14,641	28,896	2,423	44,649	6,752	1,260

(contd....)

APPENDIX IX (Contd.....)

1	2	3	4	5	6	7	8	9	10	11	12	13
Varanasi	1,14,733	5,513	23,049	18,895	66,539	43,155	20,125	68,248	43,819	16,530	16,495	934
Mirzapur	1,01,711	5,123	16,341	18,206	48,019	46,026	31,263	17,798	17,515	23,612	8,404	5,304
Jaunpur	58,816	6,226	12,724	1,01,059	62,690	89,452	9,368	7,37,283	62,132	20,102	20,918	33
Ghazipur	65,888	6,089	31,626	6,725	39,282	49,223	27,459	5,97,253	22,736	21,868	22,879	180
Ballia	45,503	2,031	7,392	24,137	44,610	49,901	32,412	6,58,242	24,577	12,066	18,827	162
Gorakhpur	2,55,904	59	258	8,668	2,13,264	38,183	2,905	12,35,763	39,002	1,409	24,745	5,065
Deoria	1,54,640	499	1,931	21,600	1,43,079	39,525	6,834	32,39,722	23,882	4,066	26,119	1,252
Basti	2,34,349	2	25	12,929	2,50,000	33,228	12,424	12,14,423	44,176	650	56,593	2,310
Azamgarh	1,62,624	247	1,094	18,541	64,040	1,21,310	12,423	13,69,161	40,758	17,670	46,906	121
Naini Tal	1,12,830	113	136	32,167	95,364	1,236	8,926	17,00,681	2,799	234	6,493	13,939
Lucknow	29,063	10,559	6,838	12,160	66,183	7,683	14,861	96,704	32,372	9,246	4,109	5,655
Unnao	51,081	17,637	5,837	35,303	1,21,647	53,657	27,823	2,18,930	21,581	24,196	8,831	13,868
Rae Bareli	81,598	22,822	8,356	1,504	83,329	59,169	23,253	89,422	18,670	25,796	12,960	4,797
Sitapur	70,750	6,436	5,839	17,514	1,58,890	27,747	48,952	15,23,763	16,021	6,113	11,263	24,866
Hardoi	53,477	27,754	7,016	64,307	2,01,520	45,788	48,788	8,98,484	38,889	17,904	13,590	42,062
Kheri	68,091	5,259	2,966	40,533	1,08,269	12,556	31,422	31,04,495	11,655	5,683	7,699	10,778
Faizabad	88,279	4,296	204	9,784	89,590	17,390	22,800	10,54,059	48,506	5,103	26,264	195
Gonda	1,60,275	722	1,222	76,120	16,010	14,370	31,208	9,18,897	28,183	2,930	31,880	5,028
Bahraich	1,21,096	400	750	1,10,419	1,36,035	22,453	29,731	2,20,274	10,396	1,112	8,423	12,263
Sultanpur	1,06,874	7,361	2,604	5,368	68,495	47,980	27,435	3,90,533	36,071	17,601	21,816	112
Pratapgarh	62,122	6,596	19,300	2,282	41,522	56,903	18,196	1,77,307	29,977	32,663	23,286	194
Bara Banki	1,02,846	5,209	4,500	10,891	1,20,394	14,177	59,020	7,57,440	41,293	5,128	11,061	2,396
Uttar Pradesh	36,05,156	4,85,994	8,81,881	17,98,662	74,23,192	14,30,499	15,43,965	5,46,72,253	14,60,571	6,78,514	8,40,308	3,63,810

Source: Bulletin of Agricultural Statistics for U.P. 1970-71, Directorate of Agriculture, U.P., Lucknow.

APPENDIX X

Districtwise growth rates in productivity indices - Based on four indices in U.P.

(Per cent per annum)

Name of district	1950-51 and 1960-61				1960-61 and 1970-71			
	1	2	3	4	1	2	3	4
1	2	3	4	5	6	7	8	9
Dehra Dun	-2.44	8.19	0.25	8.84	-0.50	0.37	9.60	10.88
Saharanpur	0.09	5.27	1.95	7.65	-0.24	0.77	9.59	6.69
Muzaffarnagar	0.08	5.65	3.15	7.84	-0.26	0.88	9.68	8.36
Meerut	0.97	3.78	2.63	7.55	-0.00	-0.03	10.04	8.64
Bulandshahr	1.30	5.23	3.50	9.15	2.38	-4.79	7.30	4.17
Aligarh	1.72	7.26	4.88	11.77	4.57	-1.88	9.00	5.31
Mathura	3.80	7.43	5.31	10.47	1.38	-1.97	8.36	6.88
Agra	2.11	4.78	4.78	9.51	-3.05	-3.03	9.81	3.72
Mainpuri	-1.15	2.01	5.61	6.59	0.56	-0.71	10.11	6.57
Etah	2.35	-0.64	4.05	3.82	1.79	2.49	9.69	10.13
Bareilly	1.87	3.45	3.57	7.64	0.29	-0.04	9.89	8.45
Bijnor	0.29	4.38	2.55	6.85	-0.68	1.69	10.37	9.78
Budaun	-0.02	-3.55	-2.69	-0.21	1.24	5.15	15.30	14.03
Moradabad	-0.07	4.55	3.24	7.79	0.79	-1.05	9.35	8.37
Shahjahanpur	0.72	2.20	2.96	6.94	-0.07	1.37	10.67	10.26
Pilibhit	-1.54	3.02	2.28	9.01	0.74	1.86	11.50	10.22
Rampur	0.38	1.66	0.71	6.76	1.18	-0.34	11.64	7.71
Farrukhabad	0.88	0.72	2.83	4.16	1.07	1.00	12.40	9.89
Etawah	-0.36	0.84	5.77	6.61	1.05	-0.95	7.42	6.96
Kanpur	0.15	2.14	5.95	6.25	0.12	1.11	7.12	7.89
Fatehpur	1.33	3.23	7.20	3.89	-0.93	0.50	6.92	10.06
Allahabad	1.63	4.31	9.31	3.90	-1.67	-1.39	6.91	8.65
Jhansi	0.77	2.46	5.12	4.84	-1.88	0.00	8.35	9.59
Jalaun	1.70	1.18	4.05	1.97	-3.76	0.54	8.61	11.00
Hamirpur	0.12	1.68	5.35	0.94	-1.75	0.25	8.56	9.50

(contd....)

APPENDIX X (Contd...)

1	2	3	4	5	6	7	8	9
Banda	1.11	1.60	4.38	-0.65	-2.68	0.29	10.83	8.25
Varanasi	1.93	2.98	5.22	4.82	-1.75	0.95	11.03	11.15
Mirzapur	3.81	2.38	3.22	2.22	-2.05	0.00	10.28	7.78
Jaunpur	-0.53	2.98	6.23	3.52	0.44	-0.39	8.92	12.03
Ghazipur	1.87	7.35	9.20	7.80	-1.19	0.80	10.32	12.39
Ballia	-0.06	4.46	5.15	5.93	-0.70	-0.37	9.50	9.32
Gorakhpur	0.28	7.81	6.04	8.94	2.03	0.49	10.21	12.22
Deoria	-0.88	6.78	3.82	8.54	0.60	-1.21	10.71	11.47
Basti	0.05	8.15	6.11	7.72	1.16	-1.30	8.83	11.36
Azamgarh	-1.46	5.71	5.39	8.28	-0.10	-1.63	8.28	9.71
Naini Tal	2.76	11.79	5.79	15.97	0.50	1.90	8.79	13.97
Lucknow	0.01	0.35	2.00	9.47	-1.09	1.92	10.41	10.89
Unnao	-1.02	-1.51	3.10	1.35	-1.99	-0.41	8.18	9.77
Rae Bareli	0.06	0.41	2.65	2.51	-1.30	0.40	8.20	10.25
Sitapur	-1.58	2.85	1.11	4.35	-0.23	1.90	10.71	10.45
Hardoi	1.77	-0.54	3.44	3.36	1.78	2.37	11.56	12.13
Kheri	-0.72	4.15	1.41	8.30	1.64	2.33	10.91	11.90
Faizabad	-0.54	3.04	5.65	6.01	-2.54	-0.06	8.82	10.86
Gonda	-0.31	12.30	2.50	13.70	0.05	-10.29	11.55	-0.50
Bahraich	-0.80	0.00	0.14	5.22	0.55	4.44	11.55	13.62
Sultanpur	-0.43	2.03	3.52	4.16	-0.55	0.10	9.73	10.29
Pratapgarh	1.37	-0.32	5.93	1.32	0.92	1.98	10.10	13.96
Bara Banki	1.71	2.89	5.50	4.82	-1.10	1.03	9.54	10.76
Uttar Pradesh	-	4.25	4.72	4.82	-	-0.28	10.23	10.76

1. Growth rate based on Yang's yield index.
2. Growth rate based on Standard Nutrition Unit.
3. Growth rate based on output per hectare.
4. Growth rate based on output per worker.

APPENDIX XI

Districtwise number of agricultural workers in U.P.

Name of district	1951	1961	1971
1	2	3	4
Dehra Dun	63,912	68,535	74,470
Saharanpur	2,65,698	2,46,901	3,87,880
Muzaffarnagar	2,86,915	2,66,944	3,79,274
Meerut	5,10,152	4,07,808	4,95,225
Bulandshahr	4,35,720	3,64,444	3,98,320
Aligarh	4,08,261	3,29,732	3,97,523
Mathura	2,67,705	2,35,236	2,50,781
Agra	3,73,538	2,82,418	3,29,296
Mainpuri	3,76,036	2,89,586	3,29,734
Etah	4,11,178	3,21,514	3,71,656
Bareilly	4,21,350	3,37,610	3,96,615
Bijnor	2,29,056	2,12,656	2,91,324
Budaun	5,20,168	4,09,666	4,59,958
Moradabad	5,39,992	4,50,446	5,23,080
Shahjahanpur	3,97,371	3,15,895	3,53,926
Pilibhit	1,87,986	1,53,493	1,95,704
Rampur	1,84,881	1,72,814	2,12,300
Farrukhabad	4,08,684	2,32,439	3,52,224
Etawah	3,85,670	2,98,749	3,19,529
Kanpur	4,88,258	4,03,231	4,53,467
Fatehpur	3,24,195	3,81,443	3,74,903
Allahabad	6,13,469	8,16,957	7,04,983
Jhansi	2,52,484	3,03,040	2,83,246
Jalaun	1,85,625	1,96,066	1,89,002
Hamirpur	2,06,897	2,79,575	2,75,192
Banda	2,80,231	3,65,897	3,61,804
Varanasi	5,11,234	5,17,200	4,98,480
Mirzapur	2,96,747	4,30,966	4,38,872

(contd.....)

APPENDIX XI (Contd.....)

1	2	3	4
Jaunpur	5,53,343	5,87,345	4,57,078
Ghazipur	3,63,215	4,13,456	3,81,062
Ballia	3,59,780	3,62,257	3,74,514
Gorakhpur	8,59,914	9,60,618	8,46,480
Deoria	9,01,851	8,78,300	7,61,609
Basti	10,13,914	11,97,104	9,56,890
Azamgarh	7,86,564	7,61,830	6,87,205
Naini Tal	1,09,130	1,69,665	1,72,130
Lucknow	4,74,952	2,36,552	2,24,493
Unnao	4,33,234	4,05,591	3,90,096
Rae Bareli	4,31,721	5,04,774	4,27,783
Sitapur	5,78,718	4,91,513	5,48,339
Hardoi	5,75,545	4,77,096	5,09,249
Kheri	4,55,896	3,89,924	4,40,898
Faizabad	5,68,387	5,64,706	5,17,931
Gonda	7,71,445	8,34,136	7,32,095
Bahraich	5,84,607	5,90,392	5,67,646
Sultanpur	4,96,225	5,03,015	4,61,868
Pratapgarh	4,13,487	4,99,050	3,81,646
Bara Banki	5,05,814	5,18,357	4,91,230
Uttar Pradesh	1,92,55,116	2,05,36,942	2,04,29,030

Source: 1. Census of India - 1951, Vol.II, Uttar Pradesh,
2. Census of India - 1961, Union Primary Census Abstract, Vol.I,
3. Census of India - 1971, Uttar Pradesh Provisional Population Totals, Paper I of 1971, Series 21.

APPENDIX XII

Districtwise details of irrigation U.P. -1970-71

(Area in hectares)

Name of district	Canals	Tube-wells	Other sources	Net irrigated area	Area irrigated more than once	Gross irrigated area
1	2	3	4	5	6	7
Dehra Dun	7,988	782	7,680	16,450	10,741	27,191
Saharanpur	83,105	78,944	24,297	1,86,346	58,593	2,44,939
Muzaffarnagar	1,32,616	94,107	24,007	2,50,730	91,288	3,42,018
Meerut	1,66,427	52,130	64,467	3,80,024	1,67,163	5,47,187
Bulandshahr	90,985	1,27,329	71,619	2,89,933	90,811	3,80,744
Aligarh	1,00,840	1,33,972	74,071	3,08,883	78,667	3,87,550
Mathura	1,23,086	50,302	26,677	2,00,065	22,741	2,22,806
Agra	59,960	62,569	35,395	1,57,924	8,436	1,66,360
Mainpuri	70,394	48,044	65,569	1,84,007	20,041	2,04,048
Etah	69,266	43,884	68,526	1,81,676	36,704	2,18,380
Bareilly	73,532	13,976	29,789	1,17,297	23,893	1,41,190
Bijnor	8,193	84,678	20,848	1,13,719	17,458	1,31,177
Budaun	-	78,001	77,823	1,55,824	15,729	1,71,553
Moradabad	3,842	92,692	1,16,499	2,13,033	28,675	2,41,708
Shahjahanpur	37,345	28,537	28,932	94,814	20,070	1,15,273
Pilibhit	41,563	14,760	8,890	61,182	13,199	74,381
Rampur	17,987	17,601	6,402	41,990	14,538	56,528
Farrukhabad	29,617	60,163	39,174	1,28,918	20,490	1,49,409
Etawah	89,931	19,578	36,849	1,46,358	21,812	1,68,170
Kanpur	1,07,819	19,599	18,861	1,46,279	16,720	1,62,999
Fatehpur	37,950	4,529	46,701	89,180	8,512	97,692
Allahabad	42,450	35,737	52,556	1,33,333	15,426	1,48,759
Jhansi	55,492	158	44,394	1,00,044	3,332	1,03,464
Jalaun	1,18,311	123	1,036	1,19,470	4,642	1,24,113
Hamirpur	73,340	171	7,705	81,216	887	82,199
Banda	82,124	536	865	83,525	10,321	95,151
Varanasi	49,394	30,802	77,790	1,57,986	22,870	1,08,856

(contd.....)

APPENDIX XII (Contd...)

1	2	3	4	5	6	7
Mirzapur	71,205	5,921	20,631	97,757	8,465	1,06,222
Jaunpur	11,844	74,188	75,513	1,61,545	6,578	1,68,123
Ghazipur	8,817	36,748	58,761	1,04,326	12,451	1,16,778
Ballia	25,853	31,306	41,603	98,762	8,149	1,06,911
Gorakhpur	13,262	53,155	1,31,741	1,98,158	7,749	2,05,907
Deoria	2,076	98,090	98,333	1,98,499	58,071	2,56,570
Basti	22,815	94,162	1,83,992	3,00,069	47	3,00,116
Azamgarh	19,673	54,661	1,57,480	2,31,814	7,781	2,39,595
Naini Tal	56,180	8,840	1,116	66,136	20,105	86,241
Lucknow	35,360	6,752	16,814	58,926	13,444	72,370
Unnao	74,208	4,526	22,454	1,01,188	14,996	1,16,184
Rae Bareli	66,078	7,253	55,096	1,28,427	19,274	1,47,701
Sitapur	48,594	22,001	24,646	95,241	876	96,117
Hardoi	44,747	20,879	14,417	80,043	6,649	86,692
Kheri	14,646	32,772	6,379	53,797	1,872	55,669
Faizabad	30,956	42,883	84,798	1,58,637	21,306	1,79,943
Gonda	219	24,698	1,08,744	1,33,661	17,717	1,51,378
Bahraich	-	19,594	27,744	47,338	324	47,662
Sultanpur	21,952	14,434	88,485	1,25,171	3,431	1,28,602
Pratapgarh	26,826	217	71,606	98,649	7,467	1,06,116
Bara Banki	53,794	18,075	36,092	1,07,961	19,655	1,27,616
Uttar Pradesh	24,22,663	19,65,248	23,98,791	67,88,191	11,00,166	78,88,357

APPENDIX XIII

Systemwise details of canal irrigation in U.P.-1970-71

(Area in hectares)

Name of district	Name of system	Agricultural command area	Actual irrigated area	Percentage (3/4 x 100)
1	2	3	4	5
Dehra Dun	Dun Canal	15,804	15,240	96.43
Saharanpur	Upper-Ganga Canal	45,144	49,910	
	Eastern-Yamuna Canal	67,444	79,445	
	Total	1,12,588	1,44,595	128.42
Muzaffarnagar	Upper-Ganga Canal	90,448	1,19,154	
	Eastern-Yamuna Canal	82,421	63,708	
	Total	1,72,869	1,82,862	105.78
Meerut	Upper-Ganga Canal	220,740	1,71,566	
	Eastern-Yamuna Canal	67,070	63,894	
	Agra Canal	80	58	
	Total	2,87,890	2,35,518	81.80
Bulandshahr	Upper-Ganga Canal	2,14,070	1,38,949	64.90
Aligarh	Upper-Ganga Canal	1,96,371	1,33,493	67.97
Mathura	Upper-Ganga Canal	1,12,635	56,525	
	Agra Canal	1,40,672	81,099	
	Total	2,53,307	1,37,624	54.33
Agra	Upper-Ganga Canal	49,401	14,881	
	Agra Canal	1,00,536	49,888	
	Total	1,49,937	64,769	43.19

(contd....)

APPENDIX XIII (Contd....)

1	2	3	4	5
Mainpuri	Upper-Ganga Canal	6,318	6,867	
	Lower-Ganga Canal	1,35,772	85,320	
	Total	1,42,090	92,187	64.87
Etah	Upper-Ganga Canal	57,055	42,214	
	Lower-Ganga Canal	80,566	48,866	
	Total	1,37,621	91,080	66.18
Bareilly	Sarda Canal	1,61,181	77,647	
	Rohilkhand Canal	49,388	23,240	
	Rampur Canal	2,522	430	
	Total	2,13,091	1,01,317	47.54
Bijnor	Bijnor Canal	9,955	9,166	
	Afzalgarh Canal	10,000	2,888	
	Ramganga Pump Canal	8,017	2,070	
	Pili Dam Canal	15,145	2,338	
	Total	43,117	16,462	38.17
Budaun	-	-	-	
Moradabad	Pili Dam Canal	2,376	24	
	Rampur Canal	52	46	
	Ramganga Pump Canal	22,823	3,259	
	Tumaria Prasar Canal	32,687	5,618	
	Tumaria Canal	26,246	9,356	
	Tarai Canal	5,557	1,428	
	Total	89,741	19,731	21.98
Shahjahanpur	Sarda Canal	1,83,973	58,660	31.88
Pilibhit	Sarda Canal	1,11,324	58,374	
	Tarai Canal	28	10	
	Rohilkhand Canal	5,874	3,819	
	Total	1,09,986	46,935	42.67

(contd....)

APPENDIX XIII (Contd....)

1	2	3	4	5
Rampur	Rampur Canal	1,09,788	46,493	
	Rohilkhand Canal	79	194	
	Tarai Canal	198	248	
	Total	1,09,986	46,935	42.67
Farrukhabad	Lower-Ganga Canal	87,990	44,366	50.42
Etawah	Lowor-Ganga Canal	1,90,473	1,08,268	56.84
Kanpur	Lower-Ganga Canal	2,65,973	1,38,940	52.23
Fatehpur	Lower-Ganga Canal	1,45,104	51,326	35.37
Allahabad	Lower-Ganga Canal	61,578	11,369	
	Sarda Canal	49,016	27,422	
	Belan Canal	93,748	27,722	
	Total	2,04,342	66,513	32.54
Jhansi	Betwa Canal	62,066	28,243	
	Pahuj & Garhmau Canals	15,136	4,764	
	Rampur (Saprar) Canal	30,981	6,410	
	Govind Sagar (Lalitpur Canal)	40,416	8,519	
	Gursarai Canal	56,738	10,167	
	Syavari Canal	7,279	2,591	
	Barhawar Canal	7,160	2,670	
	Total	2,19,776	63,364	28.83
Jalaun	Betwa Canal	2,89,534	1,56,416	54.02
Hamirpur	Betwa Canal	18,716	5,445	
	Dhasan Canal	96,044	42,112	
	Arjun Canal	48,279	12,717	
	Kabrai Canal	15,754	2,104	
	Total	1,81,293	62,378	34.40
Banda	Ken Canal	1,31,030	1,16,958	89.26

(contd....)

APPENDIX XIII (Contd....)

1	2	3	4	5
Varanasi	Ghaghara & others	90,294	94,038	
	Sarda Canal	2,279	156	
	Total	92,573	94,194	101.75
Mirzapur	Dhori Canal	3,417	1,127	
	Karmnasa & others	14,680	73,884	
	Sukhra Canal	2,512	530	
	Duddhi Canal	3,551	1,675	
	Total	24,160	77,216	319.60
Jaunpur	Sarda Canal	78,365	17,788	
Ghazipur	Karmnasa & others	11,390	6,282	
	Ramgarh Pump Canal	6,165	1,402	
	Total	17,555	7,684	43.78
Ballia	Dohrighat Pump Canal	75,816	33,158	
	Surhatal Pump Canal	8,800	3,220	
	Total	84,616	36,378	42.99
Gorakhpur	Rohin Canal	8,698	2,609	
	Danda Canal	3,698	1,310	
	Kuwano Canal	10,862	1,824	
	Ramgarh Pump Canal (E & W)	3,497	658	
	Bhakira Pump Canal (II)	8,045	1,094	
	Narayani Canal	29,020	10,348	
	Total	63,820	17,843	27.95
Deoria	Narayani Canal	7,920	1,374	17.34
Basti	Banganga Canal	26,552	15,720	
	Kuwano Pump Canal	9,118	2,320	
	Bhakira Pump Canal (I & II)	5,339	1,230	

(contd....)

APPENDIX XIII (Contd....)

1	2	3	4	5
	Basti Pump Canal	4,516	1,326	
	Zamindari Canals	20,862	9,182	
	Total	66,387	29,778	44.85
Azamgarh	Sarda Canal	36,887	5,893	
	Dohrighat Pump Canal	27,520	11,740	
	Tanda Pump Canal	35,842	2,320	
	Surhatal Pump Canal	2,724	964	
	Ratoi and Pakri Pump Canal	414	236	
	Salonatal Pump Canal	2,594	537	
	Total	1,05,981	21,690	20.46
Naini Tal	Tumaria Extension	4,400	2,771	
	Tumaria Canal	624	239	
	Sarda Canal	1,302	165	
	Rohilkhand Canal	12,043	918	
	Hilly Canal	373	1,498	
	Rampur	351	112	
	Pili Canal	132	668	
	Tarai Canal	37,984	35,996	
	Total	57,209	42,369	74.06
Lucknow	Sarda Canal	1,23,698	48,729	39.39
Unnao	Sarda Canal	2,46,287	99,414	40.36
Rae Bareli	Sarda Canal	2,46,789	78,552	31.82
Sitapur	Sarda Canal	2,41,998	48,564	20.06
Hardoi	Sarda Canal	2,86,052	79,279	27.71
Kheri	Sarda Canal	87,556	17,861	20.39
Faizabad	Ghaghara Canal	58,250	22,270	
	Sarda Canal	2,132	620	

(contd.....)

4

APPENDIX XIV

Districtwise details of food crops area under irrigation in U.P. - 1970-71

(Area in hectares)

Name of district	Rice	Jowar	Bajra	Maize	Wheat	Barley	Gram	Sugarcane	Potato	Arhar	Pulses	Oilseeds
1	2	3	4	5	6	7	8	9	10	11	12	13
Dehra Dun	9,504	-	-	815	9,192	132	146	4,138	441	1	3	534
Saharanpur	57,835	6	34	1,758	1,14,758	146	1,197	60,133	732	5	30	287
Muzaffarnagar	31,607	94	126	12,966	1,29,696	203	4,594	1,10,081	1,091	14	140	105
Meerut	18,103	770	961	58,316	2,04,373	1,945	1,232	1,34,646	5,887	173	435	115
Bulandshahr	4,844	2,964	1,324	76,242	1,76,536	14,475	9,915	47,319	4,055	290	398	1,299
Aligarh	7,998	1,163	755	43,377	2,00,244	35,740	15,769	17,581	2,671	187	94	1,278
Mathura	2,900	843	258	4,503	1,41,953	23,012	8,063	17,518	821	192	26	409
Agra	829	97	359	749	1,17,051	8,069	14,227	4,517	1,538	41	32	9,574
Mainpuri	18,843	440	235	11,167	1,21,255	9,385	16,994	3,435	5,942	48	17	4,676
Etah	5,406	491	275	15,712	1,25,299	9,709	16,304	6,011	3,836	34	20	610
Bareilly	43,629	20	13	248	71,895	387	6,549	18,090	1,890	10	7	655
Bijnor	8,924	1	3	369	70,823	376	2,830	47,257	920	3	8	1,213
Budaun	717	4	17	251	1,19,441	1,998	13,914	15,016	3,762	6	5	3,141
Moradabad	7,501	24	116	9,662	1,76,844	1,452	6,432	49,175	3,445	13	13	527
Shahjahanpur	19,727	27	14	72	41,800	1,590	6,178	18,054	2,877	12	1	488
Pilibhit	28,130	-	-	12	41,254	215	1,236	12,850	662	3	1	488
Rampur	17,078	-	-	69	85,910	612	2,339	5,477	1,167	-	1	182
Farrukhabad	4,627	15	70	8,064	89,939	4,200	11,323	5,427	22,441	33	13	2,004
Etawah	34,962	153	81	4,144	87,172	3,831	7,607	5,889	4,399	46	13	6,506
Kanpur	35,402	22	3	1,064	43,971	7,720	8,820	5,670	5,305	14	14	7,638
Fatehpur	11,366	-	-	51	62,160	30,393	7,321	7,881	1,910	-	-	349
Allahabad	16,626	12	56	63	67,212	36,578	10,234	5,040	7,632	13	1	87
Jhansi	1,636	29	-	3	71,937	5,770	25,230	983	729	9	1	125
Jalaun	7,136	56	3	12	38,260	2,842	41,691	1,865	438	19	25	2,072
Hamirpur	603	-	-	-	16,330	1,573	34,380	2,086	97	-	1	383
Banda	70,014	1	-	-	47,925	1,004	11,512	912	224	1	2	60

(contd.....)

APPENDIX XIV (Contd....)

1	2	3	4	5	6	7	8	9	10	11	12	13
Varanasi	51,525	1	21	47	17,847	36,716	6,161	18,616	4,655	23	-	25
Mirzapur	74,682	-	1	143	17,847	6,273	2,776	3,981	1,843	-	-	57
Jaunpur	1,285	-	-	1	50,796	76,923	2,232	18,128	6,616	-	-	28
Ghazipur	8,562	-	-	17	27,133	41,752	8,120	15,439	2,421	-	-	95
Ballia	608	-	-	1	29,447	29,572	12,982	15,492	2,592	-	-	34
Gorakhpur	995	-	-	2	1,64,744	23,571	6,032	16,211	4,006	-	-	1,960
Deoria	299	-	-	-	1,26,667	31,071	7,086	26,860	2,147	-	-	269
Basti	2,082	-	-	1	1,70,256	27,439	10,596	27,355	4,500	-	-	3,484
Azamgarh	1,907	-	-	71	49,498	92,718	11,844	36,129	4,323	-	-	117
Naini Tal	32,912	-	-	15	42,328	363	934	8,750	147	-	9	7,527
Lucknow	9,369	14	6	125	42,326	3,746	2,207	2,339	3,402	2	-	51
Unnao	30,777	4	-	363	64,904	20,545	8,006	5,777	2,239	2	1	516
Rae Bareli	26,057	-	23	147	66,277	31,965	2,551	2,802	1,987	16	1	929
Sitapur	3,038	-	8	9	74,623	3,906	4,445	10,448	1,559	-	2	92
Hardoi	2,318	1	-	93	85,074	10,428	12,579	15,287	4,077	1	-	797
Kheri	1,440	1	-	20	45,942	1,134	2,633	13,711	820	-	2	1,185
Faizabad	4,487	-	5	17	90,373	18,953	4,283	24,233	5,157	8	3	125
Gonda	31	-	-	-	86,448	8,1[illegible]8	18,716	9,116	2,295	-	-	2,475
Bahraich	35	-	-	-	43,557	3,728	3,953	418	707	-	-	1,338
Sultanpur	1,336	-	-	-	54,127	30,4[illegible]1	4,029	9,236	3,825	-	-	106
Pratapgarh	9,063	-	-	-	28,609	40,134	851	4,270	3,192	-	-	160
Bara Banki	16,145	1	2	36	79,263	3,716	2,724	10,582	4,372	6	2	96
Uttar Pradesh	7,44,800	7,254	4,769	2,50,797	39,87,792	7,36,418	4,32,855	9,02,231	1,51,794	1,227	5,66,745	67,911

APPENDIX XV

Districtwise details of food crops area under high yielding varieties in U.P. - 1970-71

(Area in hectares)

Name of district	Rice	Jowar	Bajra	Maize	Wheat	Barley	Gram	Peas
1	2	3	4	5	6	7	8	9
Dehra Dun	3,622	-	-	4,493	2,779	-	77	114
Saharanpur	37,260	-	7,611	7,009	30,347	-	269	376
Muzaffarnagar	12,495	1,367	6,157	10,947	41,735	-	3,518	2,110
Meerut	9,527	3,106	11,827	37,335	71,323	1,800	3,840	5,995
Bulandshahr	3,648	10,031	25,763	47,667	53,860	6,219	3,324	7,061
Aligarh	8,398	7	1,920	31,758	62,008	9,893	4,178	8,312
Mathura	903	4,019	11,702	4,488	44,388	3,900	2,600	9,000
Agra	2,903	2,036	23,890	1,815	31,378	3,025	4,400	3,800
Mainpuri	18,929	3,340	17,899	25,110	35,827	3,900	7,200	1,200
Etah	7,822	3,014	40,141	25,274	36,477	3,900	5,926	1,800
Bareilly	35,279	8,109	6,756	7,974	19,410	222	2,421	1,162
Bijnor	29,108	238	6,107	2,994	20,333	147	401	204
Budaun	16,376	5,775	32,595	16,255	37,833	1,328	4,564	3,501
Moradabad	35,444	7,190	19,624	16,381	52,566	491	2,385	3,681
Shahjahanpur	28,435	7,190	13,070	5,581	22,500	450	1,550	650
Pilibhit	33,266	1,324	1,834	1,683	10,276	233	1,011	177
Rampur	25,171	5,336	2,476	20,647	11,964	165	345	123
Farrukhabad	5,224	7,793	2,608	36,328	34,702	1,665	3,484	1,798
Etawah	17,212	3,983	13,607	13,000	26,998	1,512	2,591	3,320
Kanpur	46,660	22,625	14,254	13,891	33,791	2,850	1,995	1,721
Fatehpur	13,770	18,068	2,880	588	15,729	3,832	2,940	623
Allahabad	47,119	20,083	7,299	2,257	25,274	10,786	2,114	3,757
Jhansi	7,060	70,662	-	6,277	18,681	-	-	-
Jalaun	5,798	22,401	6,900	243	22,071	-	-	-
Hamirpur	2,476	89	90	243	13,706	-	-	-
Banda	11,450	115	204	229	9,742	-	-	-

(contd.....)

APPENDIX XV (Contd....)

1	2	3	4	5	6	7	8	9
Varanasi	59,841	1,370	12,287	6,000	15,020	13,244	2,142	5,421
Mirzapur	28,526	814	12,625	2,169	3,571	1,547	745	485
Jaunpur	28,262	372	2,679	29,942	14,979	27,368	978	6,835
Ghazipur	30,380	520	9,859	2,140	8,079	14,822	3,598	5,778
Ballia	31,325	346	2,334	5,772	9,646	6,640	3,845	4,150
Gorakhpur	73,341	-	-	4,566	48,232	9,562	3,026	6,936
Deoria	645	132	115	13,654	36,287	13,424	2,337	8,323
Basti	1,27,435	-	121	9,302	57,875	8,976	5,299	20,110
Azamgarh	63,395	-	-	6,476	19,295	28,300	4,225	16,212
Naini Tal	36,196	-	-	14,541	12,093	-	-	-
Lucknow	15,444	8,433	7,783	4,997	15,614	1,049	783	525
Unnao	17,035	16,776	5,894	13,265	18,932	3,009	1,826	570
Rae Bareli	28,211	14,872	4,481	406	23,058	6,950	3,268	2,675
Sitapur	32,100	3,951	4,898	13,527	19,112	1,683	1,812	867
Hardoi	16,371	11,591	4,912	14,884	20,029	4,539	3,225	998
Kheri	28,366	3,800	2,076	18,143	13,162	490	333	87
Faizabad	75,182	-	-	6,456	33,291	560	1,200	12,000
Gonda	76,253	550	355	50,673	44,422	2,270	5,650	6,890
Bahraich	28,945	265	412	47,925	16,574	1,200	900	500
Sultanpur	49,674	589	7	3,756	20,463	7,900	1,300	5,700
Pratapgarh	27,945	-	8	1,579	13,968	12,200	1,960	4,400
Bara Banki	67,519	1,766	1,658	10,634	31,378	1,760	1,575	2,048
Uttar Pradesh	15,20,583	1,19,777	1,59,541	6,48,692	31,80,744	2,29,751	1,11,154	1,72,595

Source: Office records Directorate of Agriculture, Uttar Pradesh, Lucknow.

APPENDIX XVI

Districtwise distribution of fertilizers through different agencies in U.P. - 1970-71

(in tonnes)

Name of district	Agricultural Supply Organisation	Provincial Co-operative Federation	Cane and other Agencies	State Agro-Industrial Corporation	Private Agencies	Total of all Agencies
1	2	3	4	5	6	7
Dehra Dun	325	413	186	162	28	1,114
Saharanpur	4,327	4,406	3,581	673	2,307	15,294
Muzaffarnagar	5,699	4,132	4,438	508	3,861	18,638
Meerut	7,749	8,417	6,453	721	5,103	27,443
Bulandshahr	6,809	4,522	533	1,643	1,818	15,225
Aligarh	6,842	1,965	-	1,186	469	10,460
Mathura	2,243	1,712	-	592	313	4,860
Agra	3,072	1,325	-	1,291	448	6,142
Mainpuri	3,196	1,917	-	927	444	6,486
Etah	3,215	1,844	-	896	892	6,847
Bareilly	2,959	3,011	1,115	308	2,267	9,660
Bijnor	2,880	3,469	2,064	237	675	9,025
Budaun	3,710	1,902	357	752	1,021	7,742
Moradabad	4,023	3,754	1,580	555	2,775	12,687
Shahjahanpur	3,087	1,707	309	272	624	6,043
Pilibhit	1,497	1,437	1,461	599	676	5,670
Rampur	2,376	2,516	613	684	1,700	7,889
Farrukhabad	3,579	3,630	-	1,223	4,722	14,124
Etawah	2,821	2,562	-	287	494	6,064
Kanpur	4,378	1,639	-	336	2,204	8,557
Fatehpur	1,869	1,039	-	289	1,096	4,293
Allahabad	4,119	3,020	-	437	156	7,722
Jhansi	1,296	215	-	61	61	1,633
Jalaun	2,098	1,330	-	135	37	3,700
Hamirpur	822	182	-	-	15	1,019
Banda	872	269	-	40	20	1,201

(contd.....)

APPENDIX XVI (Contd....)

1	2	3	4	5	6	7
Varanasi	2,819	3,716	90	354	3,928	10,907
Mirzapur	1,196	1,685	-	213	339	3,433
Jaunpur	2,527	2,923	375	324	1,894	8,034
Ghazipur	2,138	1,645	-	200	859	4,842
Ballia	1,854	1,517	35	189	843	4,438
Gorakhpur	7,089	4,930	2,122	597	2,017	16,415
Deoria	5,514	6,033	5,021	883	1,867	19,370
Basti	7,638	6,480	2,717	474	2,026	19,320
Azamgarh	3,566	2,804	-	621	1,892	8,873
Naini Tal	712	2,846	1,979	989	3,460	9,986
Lucknow	1,391	1,199	58	168	2,098	4,914
Unnao	1,820	776	-	183	212	2,991
Rae Bareli	2,094	952	-	142	288	3,476
Sitapur	1,956	1,174	1,686	311	207	5,334
Hardoi	2,009	1,072	514	278	149	4,012
Kheri	1,321	883	2,856	417	342	5,819
Faizabad	4,952	4,696	781	398	3,066	12,893
Gonda	6,274	4,865	1,416	276	895	13,668
Bahraich	3,237	2,024	-	-	416	5,677
Sultanpur	3,430	2,902	-	95	875	7,302
Pratapgarh	2,612	1,975	-	45	761	5,393
Bara Banki	4,404	3,223	997	58	3,228	11,910
Uttar Pradesh	1,57,370	1,21,680	43,350	22,046	66,094	4,10,540

Source: Office records Directorate of Agriculture, Uttar Pradesh, Lucknow.

APPENDIX XVII

Districtwise distribution of agricultural machinery in U.P.-1971

Name of district	Iron plough	Tractor	Pumping set for irrigation	Thresher
1	2	3	4	5
Dehra Dun	4,791	182	13,360	78
Saharanpur	92,130	2,517	14,241	3,547
Muzaffarnagar	51,009	8,901	18,667	4,886
Meerut	39,169	4,659	13,491	8,022
Bulandshahr	7,623	1,620	11,215	5,848
Aligarh	10,376	853	6,107	2,434
Mathura	4,921	1,522	6,107	934
Agra	18,965	1,129	10,974	1,519
Mainpuri	45,103	965	8,480	1,948
Etah	33,183	718	5,299	1,134
Bareilly	50,677	579	4,745	664
Bijnor	47,628	1,036	8,387	1,880
Budaun	56,861	334	4,307	1,417
Moradabad	15,673	1,137	12,576	3,127
Shahjahanpur	45,854	516	8,344	1,097
Pilibhit	49,071	826	4,795	1,497
Rampur	17,208	1,335	4,588	804
Farrukhabad	65,959	519	7,591	1,953
Etawah	84,731	277	5,597	1,405
Kanpur	75,568	399	8,251	1,367
Fatehpur	32,434	65	4,036	1,042
Allahabad	29,658	344	5,322	338
Jhansi	462	486	1,925	225
Jalaun	3,680	1,211	793	175
Hamirpur	4,669	356	2,167	163
Banda	27,098	75	1,605	34

(contd.....)

APPENDIX XVII (Contd....)

1	2	3	4	5
Varanasi	44,378	473	5,515	1,055
Mirzapur	23,320	441	2,866	353
Jaunpur	18,010	229	6,699	916
Ghazipur	11,616	372	5,273	953
Ballia	7,336	169	2,681	884
Gorakhpur	60,998	824	10,102	3,583
Deoria	35,820	888	8,429	4,780
Basti	53,702	592	9,739	3,432
Azamgarh	74,449	260	7,791	1,576
Naini Tal	45,662	619	4,217	1,032
Lucknow	15,367	122	2,218	43
Unnao	31,477	228	4,251	538
Rae Bareli	18,451	82	4,164	402
Sitapur	43,611	317	7,530	1,712
Hardoi	65,074	350	4,828	1,023
Kheri	74,067	1,251	7,131	1,203
Faizabad	30,714	328	6,498	1,066
Gonda	34,728	705	6,739	2,332
Bahraich	52,607	268	3,641	805
Sultanpur	6,424	62	2,373	199
Pratapgarh	3,088	138	3,267	39
Bara Banki	12,024	408	3,962	2,682
Uttar Pradesh	16,81,408	43,762	3,11,887	77,949

Source: Office records Agricultural Census, Uttar Pradesh, Lucknow.

APPENDIX XVIII

Purposewise credit advanced by Primary Agricultural Credit Societies in the districts of U.P. - 1970-71

(in thousand Rs.)

Name of district	No. of Socie-ties	Short Term				Medium Term					
		Seasonal agricultural operations	Purchase of agricultural implements	Other purposes	Total	Sinking of or repair to wells	Purchase of mach-inery	Minor improve-ments in land	Purchase of cattle	Other purposes	Total
1	2	3	4	5	6	7	8	9	10	11	12
Dehra Dun	-	6,054	-	-	6,054	-	-	1,956	-	-	1,956
Saharanpur	23	29,932	-	-	29,932	-	-	259	-	-	259
Muzaffarnagar	23	12,636	2,953	1,402	17,959	91	26	24	-	68	209
Meerut	38	38,034	-	-	38,034	-	-	668	-	-	668
Bulandshahr	20	29,738	-	205	29,943	-	-	115	-	-	115
Aligarh	59	10,239	-	-	10,239	-	-	31	-	-	31
Mathura	17	20,997	-	-	20,997	1,199	500	174	257	-	2,130
Agra	7	8,017	-	-	8,017	-	-	330	-	-	330
Mainpuri	23	7,500	-	297	7,797	-	-	-	-	6	6
Etah	37	5,838	-	-	5,838	-	419	-	-	57	476
Bareilly	8	8,756	-	-	8,756	-	-	516	-	-	516
Bijnor	34	-	18,489	-	18,489	-	-	-	-	656	656
Budaun	8	8,689	-	-	8,689	153	69	137	-	11	370
Moradabad	26	20,359	-	-	20,359	-	-	118	-	-	118
Shahjahanpur	14	4,274	-	12	4,286	-	-	141	-	-	141
Pilibhit	18	4,908	-	-	4,908	-	-	9	-	-	9
Rampur	14	-	4,819	-	4,819	-	-	140	-	-	140
Farrukhabad	22	7,006	8	3,266	10,270	-	-	-	-	-	-
Etawah	15	11,503	-	1,501	13,004	-	-	963	-	-	963
Kanpur	7	2,058	224	-	2,282	6	18	-	-	-	24
Fatehpur	22	6,250	-	-	6,250	-	-	117	-	-	117
Allahabad	18	11,259	-	-	11,259	-	-	2,439	-	-	2,439
Jhansi	19	2,110	-	-	2,110	-	-	346	-	-	346
Jalaun	19	8,084	-	-	8,084	-	-	294	-	-	294
Hamirpur	15	-	-	-	-	-	-	-	406	-	406
Banda	27	1,756	-	-	1,756	-	-	300	-	-	300

(contd.....)

APPENDIX XVIII (Contd....)

1	2	3	4	5	6	7	8	9	10	11	12
Varanasi	21	14,791	-	466	15,257	-	-	872	-	-	872
Mirzapur	15	10,229	-	-	10,229	-	660	162	-	-	822
Jaunpur	7	9,758	-	-	9,758	-	-	-	-	-	-
Ghazipur	6	2,979	-	-	2,979	10	5	11	-	-	26
Ballia	4	4,317	-	389	4,706	-	-	16	-	-	16
Gorakhpur	8	10,288	-	-	10,288	-	-	176	-	-	176
Deoria	-	31,211	-	-	31,211	-	-	751	-	-	751
Basti	4	15,745	-	-	15,745	319	512	-	-	144	1,035
Azamgarh	31	7,544	-	-	7,544	-	-	499	-	-	499
Naini Tal	19	7,462	-	-	7,462	-	-	-	392	359	751
Lucknow	-	2,743	-	-	2,743	-	-	236	-	-	236
Unnao	-	2,050	-	-	2,050	30	48	530	-	-	608
Rae Bareli	-	1,662	-	2	1,664	-	-	594	-	-	594
Sitapur	-	2,828	-	-	2,828	-	31	77	15	-	123
Hardoi	8	4,377	-	-	4,377	-	-	799	-	-	799
Kheri	15	3,410	77	288	3,775	-	129	693	-	43	865
Faizabad	10	3,170	-	168	3,338	-	-	375	172	-	547
Gonda	17	7,226	-	-	7,226	40	-	60	-	23	123
Bahraich	16	3,521	-	-	3,521	-	-	247	-	58	305
Sultanpur	5	2,006	-	-	2,006	-	-	-	-	-	-
Pratapgarh	-	5,485	-	-	5,485	-	-	-	-	-	-
Bara Banki	-	5,260	-	-	5,260	-	-	588	-	-	588
Uttar Pradesh	730	4,38,257	26,635	7,996	4,75,888	1,848	2,477	18,864	2,121	1,665	26,975

Source: Office records - Registrar, Co-operative Banks, Uttar Pradesh, Lucknow.

APPENDIX XIX

Purposewise credit advanced by District Co-operative Banks in the districts of U.P. - 1970-71

(in thousand Rs.)

Name of district	Short Term				Medium Term					
	Seasonal agricultural operations	Purchase of agricultural implements	Other purposes	Total	Sinking of or repair to wells	Purchase of machinery	Minor improvements in land	Purchase of cattle	Other purposes	Total
1	2	3	4	5	6	7	8	9	10	11
Dehra Dun	8,009	-	-	8,009	-	-	1,867	-	-	1,867
Saharanpur	26,286	-	1,236	27,522	-	114	85	-	-	199
Muzaffarnagar	19,181	-	-	19,181	-	305	214	434	-	953
Meerut	36,271	-	-	36,271	-	1,063	-	-	-	1,063
Bulandshahr	41,094	-	2,085	43,179	-	1,441	-	-	-	1,441
Aligarh	12,395	-	-	12,395	-	-	649	-	-	649
Mathura	17,284	-	-	17,284	1,199	-	205	-	501	1,906
Agra	6,965	-	-	6,965	147	-	142	-	-	289
Mainpuri	8,110	-	303	8,413	-	500	91	-	-	591
Etah	4,400	-	-	4,400	-	-	470	-	-	470
Bareilly	8,192	-	-	8,192	-	-	959	-	-	959
Bijnor	16,734	-	-	16,734	-	-	815	-	-	815
Budaun	8,837	-	-	8,837	153	69	137	-	11	370
Moradabad	21,655	-	-	21,655	-	-	-	-	-	-
Shahjahanpur	3,609	-	-	3,609	-	-	90	-	-	90
Pilibhit	9,605	-	-	9,605	-	-	-	368	256	624
Rampur	2,198	-	-	2,198	-	855	1,040	-	1,123	3,018
Farrukhabad	11,055	-	-	11,055	-	-	5	-	5	5
Etawah	8,762	-	2,686	11,448	22	42	913	7	24	1,008
Kanpur	1,958	-	-	1,958	-	300	-	-	-	300
Fatehpur	7,178	-	-	7,178	12	870	430	52	16	1,380
Allahabad	14,706	-	-	14,706	-	-	865	-	-	865
Jhansi	1,293	-	-	1,293	-	-	101	-	-	101
Jalaun	4,985	-	-	4,985	-	-	-	204	-	204
Hamirpur	3,412	-	-	3,412	-	54	155	230	379	818
Banda	1,146	-	-	1,146	-	2	266	-	-	268

(contd.....)

APPENDIX XIX (Contd....)

1	2	3	4	5	6	7	8	9	10	11
Varanasi	14,979	-	-	14,979	450	-	596	-	-	1,046
Mirzapur	12,157	-	-	12,157	-	8	-	-	-	8
Jaunpur	10,592	-	-	10,592	-	-	-	-	130	130
Ghazipur	2,719	-	-	2,719	-	-	-	-	50	50
Ballia	4,499	-	112	4,611	-	-	25	-	-	25
Gorakhpur	8,694	-	-	8,694	-	-	-	-	474	474
Deoria	31,749	-	801	32,550	288	61	192	13	-	554
Basti	15,694	-	-	15,694	-	1,018	-	-	-	1,018
Azamgarh	6,825	-	-	6,825	85	-	515	35	-	635
Naini Tal	6,618	-	-	6,618	-	11	-	-	927	938
Lucknow	2,168	-	-	2,168	50	-	186	-	-	236
Unnao	1,867	-	-	1,867	30	48	655	-	154	887
Rae Bareli	1,876	-	-	1,876	6	828	-	-	-	834
Sitapur	2,721	-	-	2,721	-	-	-	-	-	-
Hardoi	4,632	-	-	4,632	78	763	-	-	250	1,091
Kheri	3,932	-	-	3,932	-	44	503	-	598	1,145
Faizabad	2,881	-	-	2,881	9	116	262	6	162	555
Gonda	6,585	-	-	6,585	-	75	15	-	-	90
Bahraich	2,799	-	318	3,118	-	5	194	-	130	329
Sultanpur	2,090	-	-	2,090	-	-	58	-	-	58
Pratapgarh	4,368	-	-	4,368	274	10	1,373	450	507	2,554
Bara Banki	6,015	-	-	6,015	-	-	1,190	-	-	1,190
Uttar Pradesh	4,75,791	-	7,541	4,83,332	2,897	8,607	16,762	3,111	6,005	37,382

Source: Office records Registrar Co-operative Banks, Uttar Pradesh, Lucknow.

APPENDIX XX

The variables - Districtwise in U.P. - 1970-71

Name of district	Productivity index (S.N.U) per 1000 ha.	Irrigation by canal %	Irrigation by tube-well %	Irrigation by other sources %	Area irrigated more than once %	Area under HYV %	Fertilisers kg./ha.	Compost Manure tons/ 1000 ha.	Agricultural workers Nos./ 1000 ha.	Animal power (bullocks) Nos./ per/ 1000 ha.	Tractors (Horse power units) per 1000 ha.	Other power appliances Nos./ 1000 ha.	Agricultural credit Rs./1000 ha.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Dehra Dun	2,190.00	48.55	4.75	46.67	65.29	30.23	13.59	187.87	940.20	700.57	66.60	169.58	2,23,057.00
Saharanpur	4,460.00	44.59	42.36	13.62	31.44	36.19	27.64	77.08	700.00	422.10	136.20	32.23	1,12,288.42
Muzaffarnagar	8,160.00	52.89	37.53	9.56	36.40	55.55	38.99	31.92	790.00	358.80	558.60	49.14	97,393.08
Meerut	6,230.00	43.79	40.03	16.15	43.98	59.84	39.03	86.82	760.00	394.10	198.60	33.05	1,59,354.33
Bulandshahr	2,130.00	31.38	43.91	24.69	31.32	48.43	26.44	65.90	679.90	413.50	84.30	19.12	1,47,613.93
Aligarh	1,050.00	32.64	43.37	23.96	25.46	42.88	17.71	25.12	646.80	334.70	42.90	13.89	61,504.08
Mathura	1,360.00	61.52	25.14	13.32	11.36	42.56	11.82	58.69	612.80	298.60	111.90	17.20	1,16,355.53
Agra	610.00	37.96	39.61	22.40	5.34	29.87	13.88	69.08	723.40	283.90	75.00	27.43	50,159.59
Mainpuri	670.00	38.25	26.10	35.62	10.89	45.87	17.07	16.96	834.90	317.70	73.80	26.40	1,59,536.12
Etah	960.00	38.12	24.15	37.70	20.20	41.22	15.31	22.03	823.70	426.10	48.00	14.25	38,536.55
Bareilly	2,280.00	62.68	11.91	25.39	20.36	32.74	22.49	64.94	937.80	471.20	39.00	12.78	1,20,020.08
Bijnor	5,290.00	7.20	74.46	18.32	15.35	29.51	22.20	39.47	730.20	586.60	73.80	25.73	99,674.73
Budaun	1,290.00	0.01	50.05	49.93	10.09	38.97	15.03	31.99	908.80	515.70	19.20	11.29	49,026.95
Moradabad	2,850.00	1.80	43.51	54.67	13.46	42.56	20.05	122.49	830.00	552.00	53.70	24.91	77,107.81
Shahjahanpur	2,110.00	39.38	30.09	30.50	21.08	32.49	14.38	24.63	952.00	473.30	36.90	25.41	27,636.13
Pilibhit	3,080.00	67.93	24.12	7.93	21.57	31.01	20.17	17.41	702.60	430.00	87.90	22.58	62,284.21
Rampur	2,280.00	42.83	41.91	15.23	34.62	37.04	29.10	89.78	795.70	429.70	184.20	21.20	66,740.63
Farrukhabad	950.00	22.97	46.66	30.34	15.89	46.41	33.72	1.75	912.30	452.40	41.40	24.71	75,416.92
Etawah	790.00	61.44	13.37	25.16	14.90	34.79	15.52	3.08	829.80	219.50	21.00	18.17	82,123.00
Kanpur	760.00	73.70	13.39	12.89	11.43	41.97	14.14	6.34	865.00	362.50	22.50	18.33	20,115.96
Fatehpur	810.00	42.55	5.07	52.35	9.54	22.55	9.29	1.95	1064.9	572.40	5.40	14.44	29,904.86
Allahabad	530.00	31.83	26.80	41.70	11.56	24.12	15.62	7.73	1148.00	817.00	16.20	9.21	56,960.20
Jhansi	370.00	55.46	0.15	44.36	3.32	21.51	3.06	44.80	802.70	1234.00	27.30	4.03	12,195.46
Jalaun	380.00	99.02	0.10	0.86	3.88	21.44	9.42	29.97	482.70	277.70	95.10	2.46	46,005.31
Hamirpur	400.00	90.30	0.21	9.47	1.09	8.51	1.95	6.90	520.30	410.60	20.40	4.39	11,657.55
Banda	350.00	98.32	0.64	1.03	12.16	7.00	2.05	17.51	618.00	415.20	3.60	2.74	8,488.91

(contd.....)

APPENDIX XX (contd.....)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Varanasi	1,210.00	31.26	19.49	49.23	14.47	38.77	23.46	13.22	1101.10	719.50	30.30	14.51	78,664.76
Mirzapur	580.00	72.83	6.05	21.09	8.65	15.22	7.21	16.36	963.90	704.80	27.60	7.06	52,222.48
Jaunpur	1,470.00	7.33	45.92	46.72	4.07	41.46	20.67	18.61	1176.00	903.30	17.40	19.58	62,896.29
Ghazipur	1,300.00	8.45	35.22	56.30	11.93	30.89	13.77	19.36	583.90	376.90	31.50	19.45	28,903.25
Ballia	1,550.00	26.17	31.69	42.11	8.25	32.97	14.44	15.57	1222.70	604.10	16.20	11.63	38,585.92
Gorakhpur	1,450.00	6.69	26.82	32.51	3.91	10.61	25.52	35.39	1297.00	773.70	37.50	20.96	51,668.61
Deoria	3,310.00	1.04	49.41	49.52	29.25	14.61	30.04	8.74	1284.30	610.10	43.80	22.26	1,21,147.06
Basti	1,210.00	7.60	31.38	61.00	1.12	8.44	24.86	4.17	1171.20	817.80	22.80	16.12	56,869.31
Azamgarh	1,670.00	8.48	23.57	67.92	3.35	37.44	15.66	14.62	1262.00	889.30	13.80	17.19	35,466.94
Naini Tal	3,720.00	84.94	13.36	1.67	30.39	42.85	21.06	32.48	595.10	412.80	66.90	18.13	74,191.30
Lucknow	690.00	60.00	11.45	28.53	22.81	45.26	24.93	67.47	1166.40	819.50	18.30	11.74	36,301.13
Unnao	700.00	73.33	4.47	22.18	14.81	28.17	9.01	14.62	1017.90	741.40	17.10	12.49	20,762.54
Rae Bareli	510.00	51.45	5.64	42.88	15.00	33.99	7.51	7.90	1113.90	847.40	6.30	11.88	20,975.71
Sitapur	1,920.00	51.02	23.10	25.86	0.91	27.23	9.94	21.46	1044.80	718.60	17.70	17.60	16,451.05
Hardoi	1,340.00	55.90	26.08	18.00	8.30	24.12	7.90	23.37	987.40	680.70	19.80	11.30	27,526.63
Kheri	3,200.00	27.22	60.91	11.84	3.47	22.48	10.17	15.56	795.40	507.50	65.40	15.03	21,662.48
Faizabad	1,650.00	19.51	27.03	53.44	13.43	53.45	32.64	48.56	1404.50	1174.80	23.10	20.51	31,775.89
Gonda	280.00	0.16	18.47	81.34	13.25	43.44	18.88	24.95	1019.80	785.50	29.10	12.62	28,176.42
Bahraich	510.00	0.01	41.39	58.70	0.68	23.27	9.31	22.21	925.10	530.50	13.20	7.24	20,169.29
Sultanpur	940.00	17.53	11.53	70.91	2.74	38.79	17.94	18.99	1154.30	960.20	4.50	6.42	19,540.12
Pratapgarh	730.00	27.19	0.21	72.57	7.56	31.37	17.29	12.42	1262.80	1110.10	13.20	10.93	46,361.48
Bara Banki	1,430.00	49.82	16.74	33.42	18.20	49.33	27.78	31.31	1177.50	786.70	28.50	15.91	43,877.74
Uttar Pradesh	1,710.00	35.68	28.95	26.90	13.94	24.02	18.10	29.69	917.20	594.40	36.00	17.67	54,675.34

APPENDIX XXI

(COMPUTER PROGRAMME)

```
// FOR
*LIST SOURCE PROGRAM
C       SAMPLE MAIN PROGRAM FOR FACTOR ANALYSES FACT
C       THE FOLLINC DIMENSION MUST BE GREATER THAN OR E. TO THE
C       PRODUCT OF M*M
        DIMENSIONX(48,13)          DIMENSIONS[illegible]
C       THE FOLLOWING DIMENSION MUST BE GREATER THAN OR EQUAL TO
C       THE  (M+1)*M/2
        DIMENSIONR(171)          DIMENSIONV(900)
C       THE FOLLOWING DIMENSION MUST BE GREATER THAN OR EQUAL TO M
        DIMENSIONTV(51)          DIMENSIONR3(13),[illegible],RR1( 3)          COMMON,MX,MY
1       FORMAT(////24H FACTOR ANALYSIS.....A4,A4// X,12HNO. OF CASES,    I6/3X, 6HNO. OF VARIABLES,I6/)
2       FORMAT(//6H MEANS/(8F15.5))
3       FORMAT(//20H STANDARD DEVIATIONS/(8F15.5))
4       FORMAT(//25H CORRELATION COEFFICIENTS )
5       FORMAT(//4H ROW,I3/(10F12.5))
6       FORMAT(///12H EIGENVALUES/(10F12.5))
7       FORMAT(//39H COMULATIVE PERCENTAGE OF EIGEN VALUES /(10F12.5))
8       FORMAT(///15H EIGEN VECTORS )
9       FORMAT(//7H VECTOR,I3/(10F10.5))
10      FORMAT(///17H FACTOR MATRIX  (,I3,9H FACTORS))
11      FORMAT(//9HVARIABLES,I3/(10F12.5))
12      FORMAT(///10H ITERATION,7X,9HVARIANCE/9H    CYCLE)
13      FORMAT(I6,F20.6)
14      FORMAT(//24H ROTATED FACTOR MATRIX (I3,9H FACTORS))
15      FORMAT(//9H VARIABLE ,I3/(10F12.5))
16      FORMAT(///23H CHECK ON COMMUNALETIES//9H VARIABLE,7X,8HORIGINAL,12X,6H FINAL,10X,11HDIFFERENCES)
17      FORMAT(I6,3F18.5)
18      FORMAT(A4,A2,I5,I2,F6.0)
19      FORMAT(//5H ONLY,I2,29H FACTOR RETAINED. NO ROTATION)
20      FORMAT(2I2)
333     FORMAT(F10.0/8F10.0/4F10.0)
444     FORMAT(13F9.2)          READ(8,20)MX,MY
100     READ(MY,18)PR,PR1,N,M,CON
C       PR- ---------- PROBLEM NO. (MAY BE ALPHAMERIC)
C       PR1-----------PROBLEM NO. (CONTINUED)
C       N-------------NO OF CASES
C       M-------------NO OF VARIABLES
C       CON-----------CONSTANT USED TO DECIDE HOW MANT EIGEN VALUES
        WRITE(MX,1)PR,PR1,N,M          READ(8,333)((X(I,J),J=1,13),I=1,48)          WRITE(5,444)((X(I,J),J=1,M3),I=1,48)          IJ
       &=1          CALLCORRE(N,M,IO,X,XBAR,S,V,R,D,B,T)          WRITE(MX,2)(XBAR(J),J=1,M)          WRITE(MX,3)(S(J),J=1,M)
C       RANGES CALCULATION.............


PAGE   1    CC080  R

        DO1000I=1,M          R3(I)=XBAR(I)+3*S(I)          R1(I)=XBAR(I)+S(I)          RR3(I)=XBAR(I)-3*S(I)
1000    RR1(I)=XBAR(I)-S(I)          WRITE(5,1001)(R3(I),I=1,M)          WRITE(5,1002)(R1(I),I=1,M)          WRITE(5,1003)(RR3(I),I=1
       &,M)          WRITE(5,1004)(RR1(I),I=1,M)
1001    FORMAT(//' RANGES   '//5X,'M+3*STD',/10(F10.4,2X)//)
1002    FORMAT(5X,'M+1*STD',/10(F10.4,2X)//)
1003    FORMAT(5X,'M 0*STD',/10(F10.4,2X)//)
1004    FORMAT(5X,'M-1*STD',/10(F10.4,2X)//)          WRITE(5,4)
        DO120I=1,M
        DO110J=1,M
        IF(I-J)102,104,104
102     L=I+(J*J-J)/2
        GOTO110
104     L=J+(I*I-I)/2
110     D(J)=R(L)
120     WRITE(5,5)I,(D(J),J=1,M)          MV=0          CALLEIGEN(R,V,M,MV)          CALLTRACE(M,R,CON,K,D)
        DO130I=1,K          L=I+(I*I-I)/2
130     S(I)=R(L)          WRITE(5,6)(S(J),J=1,K)          WRITE(5,7)(D(J),J=1,K)          WRITE(5,8)          L=0
        DO150J=1,K
        DO140I=1,M          L=L+1
140     D(I)=V(L)
150     WRITE(5,9)J,(D(IJK),IJK=1,5)          CALLLOAD(M,K,R,V)          WRITE(5,10)K
        DO180I=1,M
        DO170J=1,K          L=M*(J-1)+I
170     D(J)=V(L)
180     WRITE(5,11)I,(D(J),J=1,K)
        IF(K-1)185,185,188
185     WRITE(5,19)K
        GOTO100
188     CALLVARMX(M,K,V,NC,TV,B,T,D)          NV=NC+1          WRITE(5,12)
        DO190I=1,NV          NC=I-1
190     WRITE(5,13)NC,TV(I)          WRITE(5,14)K
        DO220I=1,M
        DO210J=1,K          L=M*(J-1)+I          S(J)=V(L)
210     CONTINUE
220     WRITE(5,15)I,(S(J),J=1,K)          WRITE(5,16)
        DO230I=1,M
230     W[illegible](5,17)I,B(I),T(I),[illegible](I)          CALLEXIT          END

CORE REQUIREMENTS FOR
 COMMON       VARIABLES   3746  PROGRAM   13[illegible]

END OF COMPILATION

// DUP

*STORE      WS UA  FACTO
CART ID 0[illegible]  DB ADDR  511A   DB CNT   00[illegible]5

// XEQ FACTO        1

*LOCALFACTO,CORRE,EIGEN,TRACE,LOAD,VARMX



FACTOR ANALYSIS.....AGR.

  NO. OF CASES      48
```

Programme No. 2

4

```
// FOR
*LI I SOURCE PROGRAM
      MULTIPLE  LINEAR  R GRESSION
      IMENSION OF M
      IMENSIONX(666)        DIMEN,IONA(48,13)                ONXBAR(13),STD(13),D(13),RY
      6,(13)
C     DIMENSION M*M
      DIMENSIONRX(169)
C     DIMENSION R(M*(M+1)/2)
      DIMENSIONR(91)
C     DIM. EQUAL TO 13
      DIMENSIONANS(13)       COMMONMX,MY
1     FORMAT(2I2)           READ(8,15)MX,MY
1     FORMAT(A4,A2,I5,2I2)
2     FORMAT(////25H MULTIPLE REGRESSION      A4,A2//    14HSELECTION      I2///)
3     FORMAT(//9H VARIABLE,5X,4HMEAN,6X,8HSTANDARD,     1HCORRELATION,  4X,
     &                 11H REGRES,ION,4X,10HSTD..ER      ,3X,1HCOMPUTED/6H    N),,18X,        9HDEVIATION,7X,6H VS.Y,7X,
     &EFFICIENT,3X,12HOF REG.COEF.,        3X,7HT.VALUE)
      FORMAT(/,I4,6F14.5)
      FORMAT(/,10H DEPENDENT)
      FORMAT(///10H INTERCEPT,13X,F13.5//23H MULTIPLE CORRELATION  ,F13.5//23H STD ERROR OF ESTIMATE,F   .5///
      FORMAT(//,21X,39HANALYSIS OF VARIANCEFOR THE REGRESSION//         5X,19HSOURCE OF VARIATION,7
     &F,10X,4HMEAN,     13X,7HF VALUE/30X,10HOF FREEDOM,4X,6HSQURES,9X,6HSQURES)
      FORMAT(/30H ATTRIBUTABLE TO REGRESSION    ,I6,3F16.5/40H            DEVIATION FROM REGRESSION        ,2F1
      FORMAT(/5X,5HTOTAL,     I6,F16.5    )
      FORMAT(36I2)
      FORMAT(/,15X,18HTABLE OF RESIDUALS//9H CASE NO.,5X,7HY VALUE,   5X,10HY ESTIMATE,6X,8HRESIDUAL
      FORMAT(I6,F15.5,2F14.5)
      FORMAT(////52H NUMBER OF SELECTION NPT SPECIFIED   JOB TERMINATED.)
      FORMAT(//51H THE MATRIX IS SINGULAR   THIS SELECTIONIS SKIPPED.)
      PROGRAMME PARAMETETS
      FORMAT(F6.2/12F6.2)
      READ(8,1)PR,PR1,N,M,NS
      ******        PR.....PROB NAME
      ******        PR1....NO. OF PROB
      ******        N......NO OF OBS.
      ******        M........NO OF VARIABLES
        ****        NS.........NO OF SELECTION
      DO4444K=1,N       READ(8,999)(X(I),I=1,M)
      DO5555J=1,M
```

PAGE 1 GG004 E

```
5555  A(K,J)=X(J)
4444  CONTINUE
888   FORMAT(1H,13F9.2)       WRITE(5,888)((A(J,I),I=1,M),J=1,N)      IO=1      CALLCORRE(N,M,IO,A,XBAR,STD,RX,R,D,B,
      IF(NS)108,108,109
108   WRITE(MX,13)
      GOTO300
109   DO200I=1,NS       WRITE(MX,2)PR,PR1,I
C   NRESI...... OPT. CODE FOR TABLE
      0   IF  NOT ,  1  IF  R QUIRED
C      NDEP..... DEPENDENT VAR.
      READ(MY,10)NRESI,NDEP,K,(ISAVE(J),J=1,K)
      K...... NO OF I   . VAR. INCLUDED
       ISAVE...... A VECTOR CONTAING THE DEP.     S. FOLLOW
      CALLORDER(M,R,NDEP,K,ISAVE,RX,RY)          MINV         ,B,
      IF(DET)112,110,112
      WRITE(MX,14)
      GOTO200
      CALLMULTR(N,K,XBAR, TD, , ,RY,ISAVE,B,SB,T,ANS)      MM K+1        WRITE(MX,3)
      DO11 I=1,K         L ISAVE(I)
      WRI  MX,4)L,XBAR(L), TD(L),RY(I),B(I),SB(I),T(I)        WRITE(MX,5)       L ISAVE(MM)        WRITE(MX,6
      STD(L)         WRITE(MX,7)  (1),ANS(2), NS(3)          WRITE(MX,8)        ANS(1)        WRITE(MX,8)
     &01,ANS(7),ANS(9)         N          SUM ANS(4)+ N          WRITE(MX,11)   M
      IF(N  SI)200,20 ,120
      WRITE(    )PR,PR1,I        WRITE(MX,10)        MM ISAV (K+1)
        DO1I  ,N
         ALL DATA(M,W)
      DO1000IJ=1,M
1000  W(IJ)=A(II,IJ)        SUM=ANS(1)
      DO130J=1,K            L ISAVE(J)
130   SUM=SUM+W(L)*B(J)           REST W(MM)-SUM
      WRITE(MX,12)II,W(MM),SUM,REST
      CONTINUE
      GOTO100
      CALLEXIT          END

 ORE REQUIREMENTS FOR
 COMMON       2  VARIABLES    1182  PROGRAM    10
 
END OF COMPILATION

// XEQ
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